ANIAK RIVER SONAR PROJECT REPORT
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by

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ABSTRACT

The Aniak River sonar project provided daily estimates of fish passage from 16 June through 3 August, 1997. User-configurable sonar continuously sampled the entire width of the river between the transducers, except for short periods when the equipment was moved or serviced. An estimated 262,522 fish passed upstream through the ensonified area during the period of operation. The peak daily passage of 14,804 fish occurred on 21 July, and the 50% passage date occurred on 17 July. The four and five year age classes of Aniak River chum salmon comprised an estimated 65.5% and 32.4% of the escapement estimate, respectively.

INTRODUCTION

The Kuskokwim River commercial salmon fishery in June and July is directed toward the harvest of chum salmon *Oncorhynchus keta*. Commercial harvests from 1988-1996 averaged 498,839 chum salmon (Table 1). Exvessel value from in-river harvests of chum salmon during the same period averaged nearly $1.0 million (Francisco et al. 1989, 1990, 1991, 1992, 1993, 1994, 1995; Burkey et al. 1996, 1997). Also during that time, an average 85,397 chum salmon were estimated to have been harvested annually for subsistence purposes (Table 2).

Management of the fishery resource requires timely estimates of run strength and escapement. Past sonar escapement estimates and aerial survey indices of abundance suggest that the Aniak River is one of the largest producers of chum salmon in the Kuskokwim drainage (Francisco et al. 1995). Prior tagging studies suggest that travel time of chum salmon migrating from the upper end of District 1 to the Aniak River sonar site is about 7 or 8 days (Burkey et al. 1997). Because of its proximity to the Kuskokwim River commercial and subsistence fisheries, the Aniak River sonar project can provide a timely estimate for management needs of the number of chum salmon escaping to spawn in that river.

Aniak River escapement data were collected using an echo counting and processing transceiver manufactured by Bendix Corporation[1] beginning in 1980. Data were collected with a single transceiver mounted on an 18.3 m artificial substrate located on the right bank and expanded to estimate total fish passage using a variety of techniques (Schneiderhan 1989). Initially, cumulative adjusted daily totals were subjectively expanded by 150% to compensate for salmon passing beyond the ensonified range. Behavior of chum salmon observed during aerial spawning surveys on the Aniak River, and visual observations of fish migration patterns reported for the Anvik River (Buklis, 1981), lead to the supposition that on the order of two thirds of the run passed through the ensonified portion of the river.

A second sonar counter was operated in 1984 to refine the expansion factor applied to the daily counts (Schneiderhan 1985). The second counter was deployed 1.5 km downstream from the existing counter and alternately operated on each bank. The proportions between daily counts at the historical site and each bank of the downstream site over a 16 day period, resulted in a new expansion factor of 162%. In addition to the expansion of daily totals, season sonar estimates were also extrapolated for salmon escapement estimated to have occurred before and after the operational period.

Gillnet test fishing provided species apportionment and age, sex, and length (ASL) information of chum and chinook salmon. Early attempts at beach seine test fishing and

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[1] Use of vendor names does not constitute product endorsement by ADF&G.

carcass sampling proved unsuccessful at obtaining adequate sample sizes for ASL data. In 1986, ASL sampling activities were discontinued to decrease operating costs. Supporting the decision to abandon chum salmon ASL data collection was previous age and sex composition data that indicated Aniak River chum salmon results were similar to commercial catch results from the lower Kuskokwim River districts (Schneiderhan 1988).

Salmon escapement objectives for the Aniak River were tentatively set at 250,000 chum and 25,000 chinook salmon in 1981, and formally established in 1982. The chum salmon objective was derived subjectively by relating historical sonar passage estimates to trends in harvest and aerial survey indices (Schneiderhan 1982b). In 1983, a review of the escapement objective based upon sonar estimates and other escapement indices suggested that the 1980-81 Aniak sonar estimates likely represented record escapements, and much smaller escapements would probably provide adequate future spawning stocks as well as for sustained harvest (Schneiderhan 1984). Species apportionment activities were discontinued in 1986 due to inadequate sample sizes (Schneiderhan 1988). Early gillnet and beach seine test fishing investigations indicated that the abundance of fish species other than chum salmon was insufficient to compromise the utility of passage estimates for making chum salmon management decisions (Schneiderhan 1981, 1982a, 1982b, 1984, 1985). In the absence of species apportionment data, the sonar based escapement objective was changed from species specific objectives to 250,000 estimated fish counts (Schneiderhan 1985). With the implementation of the Salmon Escapement Goal Policy, the Aniak River escapement objective was termed a biological escapement goal (BEG) (Buklis 1993).

In 1996, the Aniak River sonar project was redesigned to provide full river ensonification, with user configurable sonar equipment operating 24 hours per day on both banks. A new sonar data collection site was established 1.5 km downstream from the historical site. Although fish passage estimates were not apportioned by species, periodic net sampling was employed to monitor broad changes in species composition, corroborate acoustically detected abundance trends, and obtain ASL samples of chum salmon. Season sonar estimates were not extrapolated for salmon escapement that occurred before and after the operational period.

Project operations in 1997 remained the same as in 1996. Unusually low water levels and relatively poor returns of chum salmon to the Kuskokwim Area (Burkey et al. 1997) characterized both seasons. The BEG of 250,000 estimated fish counts has been carried forward to the redesigned sonar project, and will be reassessed as more information is gathered. A timetable of developmental changes for the sonar project is presented in Appendix A.1.

The objectives of the 1997 Aniak River sonar project were:

1) Collect fish abundance data with user configurable sonar equipment 24 hours per day on both banks throughout the bulk of the chum salmon migration, from approximately 16 June through 31 July.
2) Provide daily fish passage estimates in the Aniak River to fishery managers in Bethel.

3) Periodically drift a suite of gillnets to qualitatively monitor general trends in species composition, and to corroborate sonar abundance trends.
4) Collect and archive ASL samples from migrating chum salmon near the sonar site from beach seine catches.

METHODS

Site Description

The Aniak River sonar project site is located in Section 5 of T16N, R56W (Seward Meridian) approximately 19 km upstream from the mouth of the Aniak River (Figure 1). The Aniak River originates in the Aniak Lake basin about 145 km east and 32km south of Bethel, Alaska. It flows north for nearly 129 km, where it joins the Kuskokwim River 1.6 km upstream from the community of Aniak.

In order to accomplish our objective of full river ensonification, we relocated the sonar site approximately 1.5 km downstream from the historical site in 1996 (Figure 2). The river at the sonar site is characterized by broad meanders with large gravel bars on the inside bend and cutbanks with exposed soil, tree roots and snags on the outside bend. Numerous transects were conducted in the immediate vicinity of the sonar site using a Lowrance model X-16 chart recording portable fathometer to determine the exact location to deploy the sonar transducers. The river substrate at the sonar site is fine smooth gravel, sand and silt. The right bank river bottom slopes steeply to the thalweg at about 9-14 m, while the left bank slopes gradually to the thalweg at roughly 24-35 m, depending on water level.

Hydroacoustic Data Acquisition

Equipment

Sonar equipment for the right bank of the Aniak River included: 1) a Biosonics model 102 (SN 89-020) 120/420 kHz echosounder configured to transmit and receive at 120 kHz; 2) an International Transducer Co. (I.T.C.) model 5398 (SN 002) user configurable 120 kHz elliptical beam transducer configured for dual beam use as Case II (4°x9° narrow, 12°x22° wide beam); 3) two 152.4 m (500 ft) Belden model 8412 transducer cables (SN 703A, 704A); and 4) a Biosonics model 111 (SN 053) thermal chart recorder. A Nicolet model 310 (SN 4865) digital storage oscilloscope was used to examine signals from both the left and right bank systems.

We mounted the right bank transducer on an aluminum tripod and remotely aimed it with a Remote Oceans Systems (R.O.S.) model PT-25 (SN 215) oil filled, dual axis rotator. We controlled rotator movements with a R.O.S. model PTC-1 Pan and Tilt Control Unit connected to the rotator with 152.4 m of Belden 9934 pan and tilt cable. A set of digital panel meters provided readings, accurate to within ± 0.3 degrees, for the horizontal and vertical axes positions.

Left-bank sonar equipment included: 1) a Biosonics model 102 (SN 89-021) 120/420 kHz echosounder configured to transmit and receive at 120 kHz; 2) an I.T.C. model 5398 (SN 009) user configurable 120 kHz elliptical beam transducer configured for dual beam use as Case I (2°x5° narrow, 4°x9° wide beam); 3) two 304.8 m (1000 ft) Belden model 8412 transducer cables (SN 701A, 702A); and 4) a Biosonics model 111 (SN 041) thermal chart recorder.

We mounted the left bank transducer on an aluminum tripod and remotely aimed it with a R.O.S. model PT-25 (SN 1064) air filled, dual axis rotator. We controlled left bank rotator movements with the same R.O.S. PTC-1 controller used for the right bank. All electronic equipment was housed in a 3.0 m x 3.7 m (10 ft x 12 ft) portable wall tent on the right bank and powered by a single Honda model EM-3500 independently grounded generator. Transducer and rotator cables for the left bank were attached to a 6.4 mm (1/4 in) steel cable suspended 3 m above the river. The cable bundle was marked with orange flagging to allow safe boat passage.

Sampling Procedures

We conducted single beam acoustic sampling on both banks continuously 24 h per day, seven days per week, except for short periods of time in which the generator was serviced and transducer adjustments were made. Inseason analysis consisted of visually scanning the echograms for fish traces and anomalous detections to verify consistent aim. A single fisheries technician operated and monitored equipment at the sonar site. Crewmembers rotated through shifts of 0800-1630 and 1630-2400 h until 23 June, when the schedule was altered to 0000-0800, 0800-1600, and 1600-2400 h. During those shifts, crewmembers identified and tallied fish traces on chart recordings. For consistency, crewmembers were trained to distinguish between fish traces and non-fish traces, such as those from debris and bottom. The number of fish traces was summed within a given range and 15 minute period. Range intervals were 2 m wide on the right bank and 5 m wide on the left bank. Completed data forms were transported to the main camp throughout the day, and entered into Excel Version 5.0 electronic spreadsheets by the project leader. Daily estimates were transmitted via single side band radio to area managers at 0730 h the following morning. Chart recorder output constituted the only record of detected echoes and fish passage. Chart recordings were annotated for date, time, and bank, and then catalogued for storage.

We recorded project activities in a project logbook. The logbook was used to document daily events of sonar activities and system diagnostics. During each shift, crewmembers were required to: 1) read the log from the previous shift; 2) sign the log book, including date and time; 3) record equipment problems, factors contributing to problems, and resolution of problems; 4) record equipment setting adjustments and their purpose; 5) record observations concerning weather, wildlife, boat traffic, etc.; and 6) record visitors to the site, including their arrival and departure times.

Equipment Settings and Thresholds

Sound pulses were generated by the echosounders at a center frequency of 120 kHz. We used a 40 log(R) time varied gain (TVG) and a 5 kHz frequency bandwidth filter for both banks. We set the right and left bank transmit pulse width at 0.4 ms, and later changed the transmit pulse width to 0.3 ms to minimize cross-talk between transducers and increase resolution of fish traces. Maximum sampling range was 15 m on the right bank and 40 m on the left bank. The right bank chart recorder threshold was set at 0.5 volts (-40.4 dB) during all sampling activities. The left bank threshold was set at 0.6 volts (-45.9 dB). Three printer thresholds, corresponding to intensities of gray-line, on the Biosonics MDL 111 thermal printer were factory set at 6 dB intervals. Right bank printer thresholds corresponded to target strengths of -40.4 dB, -34.4 dB, and -28.4 dB (gray scale 1, 2, and 3 respectively). Left bank printer thresholds were -45.9 dB, -39.9 dB, and -33.9 dB. We altered the left bank transmit and receiver gain levels on 28 June (target strengths = -44.8 dB, -38.8 dB, and -32.8 dB) and again on 12 July (target strengths = -43.9 dB, -37.9 dB, and -31.9 dB) in response to aim changes associated with transducer relocation as water levels dropped.

Threshold levels and target strength levels were calculated as follows:

$$TS_{dB} = V_o - SL - G_X - G_R - 2B\theta \qquad (1)$$

where:

TS_{dB} = target strength in dB
V_o = volts out in dB
SL = transmitted source level in dB
G_X = through-system gain in dB
G_R = receiver gain in dB
$2B\theta$ = 2-way beam pattern factor in dB

Transmission loss was assumed to be negligible at the ensonification ranges sampled and was therefore exactly compensated by TVG.

Aiming, Deployment

The transducers were positioned in the river as nearly perpendicular to the current as possible. The wide axis of each elliptical beam was oriented as close to the horizontal position and as near the bottom of the river as possible to maximize target residence time in the beam. Transducers were placed offshore, 3 m to 4 m from the right bank, and 12 m to 19 m from the left bank. Weirs extended from shore 3 m to 5 m beyond the transducers to prevent chum salmon from passing undetected behind the transducers and to minimize detections in the nearfield (MacLennan and Simmonds 1992). The gap between weir pickets, 4.4 cm (1 ¾ in), was selected to divert chum salmon but allow passage of small, resident fish we did not want to include in the passage estimate. Daily visual inspections confirmed proper placement and orientation of the transducers.

Hydroacoustic Equipment Checks

Both sonar systems were bench calibrated in May, 1997. We estimated background noise levels in the field at several range intervals for each sonar system several times each week. Noise levels were estimated by measuring the average peak voltage in four separate range intervals on the oscilloscope. Selected range intervals were separated by noise peaks caused by structure.

Bottom Profiles and Stream Measurements

We recorded numerous bottom profiles outward from both banks using a Lowrance X-16 chart recording fathometer prior to choosing exact deployment sites. On 26 June and 14 July, we made paired depth at range measurements on both banks using the Lowrance fathometer and a Laser Atlanta model Advantage (SN 10365) optical laser range finder. Measurements were made at 2 m to 3 m intervals, from each transducer to the opposite shore.

Climatological and Hydrologic Measurements

We measured ambient air temperature, and water conductivity and temperature once per day using an Extech model 34165 Conductivity/Temperature meter. Water level was recorded daily on the right bank at the site using a staff gauge to register daily river levels. Standard secchi disk readings were taken once per day. All climatological and hydrologic measurements were recorded on a log form.

Analytical Methods

Fish Passage Estimates

Fish traces were tallied in 2 m range intervals for the right bank and 5 m intervals for the left bank in 15 minute intervals directly from the chart recordings. Data were collected on both banks 24 hours per day, 7 days per week, except for brief and infrequent periods when the sonar equipment was not operational. The full width of the river between transducers was ensonified and fish traces were not apportioned to species. No attempts were made to determine direction of travel. The number of fish traces tallied for both banks was summed with estimates for missing data to provide daily total fish passage estimates.

Missing Data

Generator maintenance, sonar equipment adjustments and malfunctions occasionally resulted in missing sonar data. When less than 10 minutes of a 15 minute interval were missed, the passage rate for the period within the interval that was sampled was used to estimate passage for the unsampled portion of the interval. Data missing from more than 10 minutes of a 15 minute interval were estimated from the average relative distribution (proportions) of passage rates 45 minutes before and after the missing block of data on that bank. When more than one hour of data were missed on both banks, the average proportions of passage rates were pooled from 6 hours before and after the missing block of data on that bank respectively. A right bank/left bank average proportion of passage rates was used to estimate fish passage when one of the sonar systems remained operational while the other was down for more than one hour.

Species Composition Verification

Equipment and Procedures

We fished two gillnets periodically at times determined inseason to monitor species composition and corroborate the presence or absence of fish traces. We used a 13.6 cm (5-3/8") mesh multifilament net measuring 12.8 m (7 fathoms) long by 3.1 m (10 feet) deep and a 7.0 cm (2-3/4") mesh multifilament net measuring 18.3 m (10 fathoms) long by 1.5 m (5 feet) deep.

Nets were fished during periods of acoustically determined low fish passage to minimize fish mortality and verify low abundance. Each net was drifted at least one time at three stations, one on the right bank and two on the left bank, during the sampling period (Figure 3). Most drifts were approximately 2-3 minutes in duration. The procedure for gillnet fishing was to deploy the net off the bow of a skiff moving from shore toward midstream, then drift downstream with the net perpendicular to shore. The net was pulled into the boat at the end of the drift, and the fish were removed, identified, and unharmed fish were released back into the river.

ASL Sampling

Equipment and Procedures

A 46 m x 3 m (150 ft x 10 ft) green 7.0 cm mesh beach seine was used to obtain ASL samples of chum salmon. We attached a long line, approximately 30 m, to one end of the seine. The seine was stacked in a plastic fish tote and placed in the stern of a skiff. We attached the opposite end of the seine to a pulley designed to pivot from the side of the skiff to the stern. As the skiff moved offshore, orientated upstream, the end of the 30 m lead was held in place by a crewmember. We moved the skiff straight offshore until all of the lead line was dispensed and the seine started to peel out of the tote. We then drove the skiff upstream and inshore, dispensing the entire length of the seine. When the skiff reached the shore, the seine was released from the pulley and allowed to drift downstream while we guided it next to the shore. The lead was pulled in just enough to form a hook shape to the offshore end of the seine (Figure 4). We drifted the entire seine in this formation for approximately 100m before we pulled in the lead line and closed the set.

All captured fish except chum salmon were tallied by species, fin clipped, and released. Chum salmon were placed in a live box for sampling. One scale was taken from the preferred area of each chum salmon for use in age determination (INPFC 1963). Scales were wiped clean and mounted on gum cards. Sex was determined by visually examining external morphological characteristics keying on the development of the kype, roundness of the belly and the presence or absence of an ovipositor. Length was measured to the nearest millimeter from mid-eye to the fork of the tail. All data were recorded in a "rite-in-the-rain" notebook and later transcribed to standard mark-sense forms.

The sampling goal was to obtain data from a sufficient number of fish, within a given period of time, to precisely estimate the true age composition of the escapement during that time (Molyneaux and DuBois 1996). A pulse sampling design was followed in which intensive sampling was conducted for one or two days followed by several days without sampling. The goal of each pulse was 200 chum salmon scales (Bromaghin 1993). All ASL data were sent to the Bethel ADF&G office for analysis by the Kuskokwim Area research biologist. Ages were reported using European notation, in which two digits, separated by a decimal, refer to the number of freshwater and marine annuli. The total age from the time of egg deposition is the sum of the two digits plus one.

To estimate the age and sex composition of the chum salmon escapement in the Aniak River, daily passage estimates were stratified. Each stratum consisted of several days of fish passage and one pulse sample. Within each stratum, estimates of the age and sex composition were applied to the sum of the chum salmon passage to generate an estimate of the number of fish in each age-sex category. The numbers of fish were summed by age-sex category over all strata to estimate the total season passage by age and sex.

RESULTS

Hydroacoustic Data Acquisition

Sampling Procedures

Sonar project activities commenced on 4 June and ended on 7 August 1997. Hydroacoustic sampling began on 16 June on both banks. With few exceptions, the equipment ran continuously, 24 hours per day, 7 days per week, until sampling ended at midnight on 3 August. Passage estimates were available to fishery managers in Bethel at 0730 h and 1700 h daily.

Data acquisition was interrupted for several minutes 3 times each day for generator refueling and maintenance. In addition to regular maintenance, a total of 34 hours (less than 3%) of sampling time were missed on the left bank due to paper jams, system diagnostic tests, generator failure, moving the tripod or reaiming the transducer to compensate for changing water levels throughout the season. Moving the tripod, generator failure, reaiming the transducer and damaged transducer cables accounted for 24 hours (less than 2 %) of missed sampling time on the right bank over the course of the season.

Typical ambient background noise levels measured -56.4 dB over most of the counting range on the right bank and –68.4 dB on the left bank. Signal to noise ratios (SNR's) of approximately 16 dB on the right bank and 22 dB to 23 dB on the left bank were common. Higher noise levels, -36.3 dB and –38.3 dB, occurred on the right and left bank over narrow range intervals where the beam grazed high points in the river bottom. Lower SNR's (4.0 dB and 7.6 dB) at these points did not unduly corrupt data collection since the goal of the acoustic sampling was only fish detection. SNR's were generally maintained above 16 dB during sampling.

Bottom Profiles and Stream Measurements

Stream measurements were calculated using a Laser Atlanta model Advantage optical laser range finder with paired magnetic direction output capacity and a Lowrance model X-16 chart recording fathometer on 26 June and 14 July. Water levels at these times were below normal. The river width at the sonar site on 26 June was 73.6 m and the maximum depth was 2.2 m (Figure 5). The right bank transducer was positioned at a 175° magnetic heading (20° East declination) and the left bank transducer was aimed at a 342° magnetic heading. Total diagonal distance between the transducers measured 55.4 m. Total ensonification range between transducers, as measured perpendicular from the face of the transducers, was 55 m and there was approximately a 12 m lateral separation between effective beam widths. When we conducted stream measurements again on 14 July, the river width was 57.3 m and the maximum depth was 1.7 m. The right bank transducer position remained at a 175° magnetic heading and the left bank transducer had changed to a 345° magnetic heading. Total distance between transducers measured 44.5 m. Total ensonification range between transducers was 42 m. With respect to the left bank transducer, the right bank transducer was positioned approximately 30 m downstream. Cross talk between transducers was observed on the left bank chart recordings, but did not interfere with data acquisition. When transducers were repositioned to compensate for changing water levels, the ensonified range was adjusted accordingly.

Analytical Methods

Fish Passage Estimates

Total passage during project sampling activities was estimated at 262,522 fish, with 47 percent passing on the right bank and 53 percent passing on the left bank (Table 3). A comparison of daily estimated passage between banks is presented in Figure 6. The peak daily passage of 14,804 fish occurred on 21 July (Figure 7). The 25%, 50%, and 75% quartile dates of passage were 6 July, 17 July and 24 July (Table 3).

We examined the hourly fish count data for evidence of daily patterns of movement during 7-day periods of data collection. During each time period, fish passage increased at night and declined during the day. As the season progressed, this tendency became more pronounced (Figure 8). Overall, seasonal range distributions of targets that passed the site peaked at 4-6 m from the right bank transducer (Figure 9) and at 5-10 m from the left bank transducer (Figure 10). Less than 1% of the right bank targets passed through the outer two meters of the right bank sampling range (Appendix A.2). The outer 5 meter sampling range on the left bank accounted for less than 3% of the left bank passage estimates. As the season progressed, the fish passage distribution on the left bank demonstrated an inshore movement (Figure 10).

Species Composition Verification

We conducted gillnet drifts during nine sampling periods to verify dominant species presence (Table 4). Sampling periods occurred when fish passage was less than 310 fish per hour and drift duration averaged two to three minutes. We made a total of 68 drifts, of which 48 were made with 13.6 cm mesh gillnets, 8 were made with 10.0 mesh gillnet, and 12 were made with 7.0 cm mesh gillnets. The total catch consisted of 31 chum salmon, 19 chinook salmon (*O. tshawytscha*), 2 sockeye salmon (*O. nerka*), and 4 longnose sucker (*Catostomus catostomus*).

ASL Sampling

We made a total of 137 beach seine sets to obtain ASL samples of migrating chum salmon (Table 5). In all, we collected data from 853 chum salmon for analysis by the Kuskokwim Area research biologist. The overall age composition of Aniak River chum salmon was typical of other Kuskokwim chum salmon populations, where the 0.3 age class dominates the return, followed by the 0.4 age class (Francisco et al. 1995). The 0.3 and 0.4 age classes comprised an estimated 65.5 % and 32.4 %, of the escapement estimate, respectively (Table 6). The tendency seen at Aniak River in 1997, of the age 0.4 chum contribution being the highest at the onset of the season and age 0.3 chum becoming progressively more dominant through the course of the season is a common pattern in the Kuskokwim drainage (Molyneaux and DuBois 1996).

DISCUSSION

Hydroacoustic Data Acquisition

Sampling Procedures

The transducers used at the Aniak River sonar project are very large due to their narrow beam width and low frequency (120 kHz). To submerge the left bank transducer, it was necessary to deploy it approximately 12-18 m offshore. Constructing and maintaining a weir to prevent fish passing undetected behind the transducer was difficult and time consuming. The use of higher (i.e. 420 kHz) sampling frequency might minimize this difficulty by allowing us to place a smaller transducer closer to shore. The extremely short sampling ranges employed at the site minimize the effect of transmission loss at this higher frequency.

Chart recordings displayed some evidence of fish occasionally passing in the near field of both transducers. Swift current and deep water prevented us from extending the weirs further than 3 – 5 m beyond the face of the transducers. The higher 420 kHz equipment would substantially reduce the nearfield range and the likelihood of fish passing in this zone.

Fish Passage Estimates

A comparison of daily passage percentages for right and left banks in 1996 and 1997 indicate seasonal changes in fish migration patterns past the sonar site. In 1996, 37% of the estimated fish passed through the left bank ensonified area and 63% passed through the right bank ensonified area. In 1997, 53% of the estimated fish passed through the left bank ensonified area and 47% passed through the right bank ensonified area.

Species Composition Verification

The Aniak River supports anadromous and resident fish populations of several different species, but the sonar estimates are not apportioned to species. While we are aware of this situation, past and current sampling efforts indicate that the abundance of fish other than chum salmon is insufficient to compromise the utility of passage estimates for making chum salmon management decisions. A 1995 Aniak River sonar test fish feasibility study indicated that a species apportionment program is logistically feasible at the current site (Knuepfer 1995). The primary consideration to implementing such a program is a budgetary one that will be reviewed prior to the 1998 field season. A secondary consideration is the potential that additional netting and fish handling may result in an unacceptable level of collateral fish mortality.

ASL Sampling

The techniques used to obtain ASL samples were designed to maximize the capture of chum salmon with the equipment on hand. Therefore, direct application of relative species abundance from beach seine data to sonar data is not recommended. The beach seine sampling area was located 1.5 km upstream of the sonar site and only the extreme nearshore portion of the river was fished for ASL samples. No attempt should be made to expand or use this data for quantitative species apportionment information.

Based on the low escapement estimate in 1993, an exceptionally weak return of Aniak River chum salmon was anticipated. Although the achievement of the escapement goal in 1997 is attributed in part to extraordinary management actions, which included a virtual absence of commercial fisheries in June and July and an appeal to subsistence fishers to voluntarily reduce their chum salmon harvest (Burkey et al. 1997), the estimated escapement of 262,522 fish past the Aniak River sonar was not expected. In addition, the overall age composition estimates of Aniak River chum salmon, 65.5% age class 0.3 and 32.4% age class 0.4, were typical of other Kuskokwim chum salmon populations and may suggest a measure of uncertainty in the 1993 escapement estimate.

Historical Data

In 1996, the Aniak River sonar project was redesigned and operations were significantly altered from past operations dating back to 1980. Estimates prior to 1996 are difficult to substantiate due to a lack of project documentation and the inability of the Bendix equipment to verify aim. Comparisons between escapement estimates generated from these two very different types of project operations could lead to misinterpretation and should not be made. The traditional BEG of 250,000 fish for the Aniak River sonar should be considered as interim under the redesigned sonar project. The goal will need to be reassessed as more information is gathered.

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Table 1. Lower Kuskokwim River, District 1 and the middle Kuskokwim River, District 2, combined commercial salmon harvest and estimated exvessel value, 1988-1997.[a]

Kuskokwim In-River Commercial Salmon Harvest (Source: 1988-95 Annual Management Reports & 1995, 1997 Reports to the Alaska Board of Fisheries)							
Year		**Chinook**	**Sockeye**	**Coho**	**Pink**	**Chum**	**Total**
1988	Fish	55,716	92,025	524,296	10,825	1,381,674	2,064,536
	Value	$974,664	$950,181	$4,570,505	$5,495	$3,781,449	$10,282,296
1989	Fish	43,217	42,712	479,856	464	749,182	1,315,431
	Value	$490,410	$376,775	$1,875,097	$80	$1,305,284	$4,047,646
1990	Fish	53,759	84,870	410,332	3,397	461,624	1,013,982
	Value	$435,052	$619,442	$1,639,224	$1,893	$824,067	$3,519,678
1991	Fish	37,778	108,946	500,935	378	431,802	1,079,839
	Value	$320,733	$512,858	$1,431,976	$157	$836,144	$3,101,868
1992	Fish	46,872	92,218	666,170	7,451	344,603	1,157,314
	Value	$397,894	$590,293	$2,150,242	$1,381	$760,934	$3,900,744
1993	Fish	8,735	27,008	610,786	64	43,337	689,930
	Value	$72,812	$140,824	$2,297,772	$59	$114,127	$2,625,594
1994	Fish	16,211	49,365	724,689	30,949	271,115	1,092,329
	Value	$126,961	$188,704	$3,002,387	$8,973	$383,630	$3,710,655
1995	Fish	30,846	92,500	471,461	93	605,918	1,200,818
	Value	$309,088	$460,982	$1,358,656	$50	$746,478	$2,875,254
1996[b]	Fish	6,973	33,512	935,510	1,621	200,298	1,177,914
	Value	$23,672	$97,622	$1,835,208	$744	$170,988	$2,128,234
1997	Fish	10,441	21,989	130,803	2	17,026	180,089
	Value	$36,888	$64,926	$315,650	$1	$19,522	$436,575
Average	Fish	33,345	69,239	591,559	6138	498,839	1,199,120
(1988-1996)	Value	$350,142	$437,520	$2,240,118	$2,092	$991,455	$4,021,327

[a] Does not include test fish sales.

[b] Does not include roe sales.

Table 2. Lower Kuskokwim River, District 1 and the middle Kuskokwim River, District 2, and the Upper Kuskokwim River combined subsistence salmon harvest, 1988-1996.

Kuskokwim In-River Subsistence Salmon Harvest

(Source: 1988-95 Annual Management Reports & 1995 Revised Report to the Alaska Board of Fisheries)

Year	Chinook	Chum	Sockeye	Coho	Total
1988[a]	53,877	117,009	23,649	28,331	222,866
1989	73,035	122,116	31,432	45,279	271,862
1990	71,281	96,274	28,926	38,991	235,472
1991	80,864	81,648	49,011	48,201	259,724
1992	58,239	85,203	29,849	36,410	209,701
1993	72,119	46,295	39,854	26,503	184,771
1994	79,688	59,255	30,619	27,005	196,567
1995	100,573	71,349	29,125	40,396	241,443
1996	78,729	89,430	34,370	33,167	235,696
Average (1988-1996)	74,267	85,397	32,981	36,031	228,678

[a] Beginning in 1988, estimate based on new formula, data not comparable to previous years.

Table 3. Daily and cumulative estimates of fish passage at the Aniak River sonar site, 1997.

1997 Season Estimates								
Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage	Percent Passage	Water vel (cm)
16-Jun	74	143	217	217	0.34	0.66	0	86.0
17-Jun	52	272	324	541	0.16	0.84	0	84.0
18-Jun	119	445	564	1,105	0.21	0.79	0	79.5
19-Jun	155	535	690	1,795	0.22	0.78	1	79.0
20-Jun	248	737	985	2,780	0.25	0.75	1	84.5
21-Jun	205	371	576	3,356	0.36	0.64	1	78.5
22-Jun	92	760	852	4,208	0.11	0.89	2	72.5
23-Jun	270	821	1,091	5,299	0.25	0.75	2	69.1
24-Jun	1,412	1,261	2,673	7,972	0.53	0.47	3	65.3
25-Jun	1,344	1,667	3,011	10,983	0.45	0.55	4	65.0
26-Jun	964	1,789	2,753	13,736	0.35	0.65	5	65.5
27-Jun	1,238	1,940	3,178	16,914	0.39	0.61	6	63.5
28-Jun	2,445	2,145	4,590	21,504	0.53	0.47	8	60.0
29-Jun	1,663	1,822	3,485	24,989	0.48	0.52	10	56.0
30-Jun	1,151	1,193	2,344	27,333	0.49	0.51	10	51.5
1-Jul	1,455	1,011	2,466	29,799	0.59	0.41	11	48.5
2-Jul	1,650	1,270	2,920	32,719	0.57	0.43	12	49.0
3-Jul	4,621	2,420	7,041	39,760	0.66	0.34	15	44.5
4-Jul	7,628	4,070	11,698	51,458	0.65	0.35	20	41.5
5-Jul	5,760	3,986	9,746	61,204	0.59	0.41	23	38.0
6-Jul	3,199	3,783	6,982	68,186	0.46	0.54	26	36.0
7-Jul	2,984	3,014	5,998	74,184	0.50	0.50	28	33.0
8-Jul	2,770	3,152	5,922	80,106	0.47	0.53	31	30.0
9-Jul	1,975	2,016	3,991	84,097	0.49	0.51	32	31.0
10-Jul	1,272	1,207	2,479	86,576	0.51	0.49	33	26.0
11-Jul	3,849	3,350	7,199	93,775	0.53	0.47	36	23.5
12-Jul	6,466	4,429	10,895	104,670	0.59	0.41	40	20.0
13-Jul	3,366	2,738	6,104	110,774	0.55	0.45	42	17.0
14-Jul	1,632	2,040	3,672	114,446	0.44	0.56	44	13.5
15-Jul	1,779	1,665	3,444	117,890	0.52	0.48	45	11.5
16-Jul	3,515	3,602	7,117	125,007	0.49	0.51	48	9.0
17-Jul	3,704	3,109	6,813	131,820	0.54	0.46	50	6.5
18-Jul	5,392	3,977	9,369	141,189	0.58	0.42	54	5.0
19-Jul	5,668	5,568	11,236	152,425	0.50	0.50	58	4.5
20-Jul	3,826	3,591	7,417	159,842	0.52	0.48	61	3.5
21-Jul	7,833	6,971	14,804	174,646	0.53	0.47	67	5.0
22-Jul	6,339	6,105	12,444	187,090	0.51	0.49	71	13.0
23-Jul	4,760	3,584	8,344	195,434	0.57	0.43	74	17.5
24-Jul	2,714	3,234	5,948	201,382	0.46	0.54	77	27.0
25-Jul	2,654	3,098	5,752	207,134	0.46	0.54	79	30.5
26-Jul	1,290	1,974	3,264	210,398	0.40	0.60	80	23.0
27-Jul	2,428	2,296	4,724	215,122	0.51	0.49	82	19.0
28-Jul	4,251	4,231	8,482	223,604	0.50	0.50	85	15.5
29-Jul	3,457	3,464	6,921	230,525	0.50	0.50	88	12.0
30-Jul	3,273	3,465	6,738	237,263	0.49	0.51	90	9.0
31-Jul	3,568	1,959	5,527	242,790	0.65	0.35	92	6.0
1-Aug	4,340	2,451	6,791	249,581	0.64	0.36	95	4.5
2-Aug	4,750	2,646	7,396	256,977	0.64	0.36	98	4.5
3-Aug	3,707	1,838	5,545	262,522	0.67	0.33	100	6.5
TOTAL	139,307	123,215	262,522	262,522	0.53	0.47		

Table 4. Aniak River sonar catch results using drift gillnets, 1997.

Date	Time of Day	# of Drifts	Mesh (cm)	Chum	King	Sockeye	Sucker
6/18/97 Fish Passage – 17/h.	1440-1532	6	7.0	0	0	0	0
6/18/97 Fish Passage – 18/h.	2124-2205	8	10.2	0	0	0	1
6/22/97 Fish Passage – 50/h.	1408-1511	10	13.6	0	0	0	0
6/24/97 Fish Passage – 91/h.	1715-1805	6	13.6	1	4	0	0
6/27/97 Fish Passage – 74/h.	1422-1458	6	13.6	1	3	0	0
7/01/97 Fish Passage – 21/h.	1030-1130	6	13.6	0	4	0	0
7/01/97 Fish Passage – 42/h.	1203-1225	3	7.0	1	0	0	0
7/07/97 Fish Passage – 189/h.	1325-1420	6	13.6	6	8	1	0
7/07/97 Fish Passage – 165/h.	1435-1455	3	7.0	1	0	0	3
7/27/97 Fish Passage – 193/h.	1715-1800	4	13.6	12	0	1	0
7/29/97 Fish Passage – 275/h.	2020-2135	5	13.6	6	0	0	0
7/30/97 Fish Passage – 307/h.	2245-2330	5	13.6	3	0	0	0

Table 5. Aniak River catch results using beach seine gear, 1997.

Date	Time of Day	# of Sets	Chum	King	Pink	Sockeye	Coho	Whitefish	Sucker	Pike	Char	Rainbow	**Total Catch**
6/30/97	0000-0230	10	11	3	0	0	0	10	12	0	2	0	**38**
Avg. Fish Passage - 187/h.													
7/02/97	0015-0200	6	18	5	0	0	0	6	10 (1 recap)	0	0	0	39
Avg. Fish Passage - 216/h.													
7/03/97	0015-0245	11	59	8	0	4	0	24	31	1	8	0	**134**
Avg. Fish Passage - 271/h.													
7/04/97	0115-0225	5	62	13	0	0	0	24 (1 recap)	31 (2 recap)	0	0	0	**133**
Avg. Fish Passage - 601/h.													
7/09/97	0130-0330	9	29	8	0	12	0	74	52 (1 recap)	2	8	0	**186**
Avg. Fish Passage - 336/h.													
7/10/97	0055-0325	10	9	3	0	7	0	30	24	0	4	0	77
Avg. Fish Passage - 173/h.													
7/11/97	0820-1240	12	59	2	0	31	0	0	3	0	7	0	**102**
Avg. Fish Passage - 388/h.													
7/12/97	0110-0300	5	94	15 (1 recap)	2	10 (1 recap)	0	88	52 (3 recap)	2	9	1	**273**
Avg. Fish Passage - 577/h.													
7/15/97	0110-0300	8	28	10	2	8	0	92	49	1	12	0	**202**
Avg. Fish Passage - 270/h.													
7/16/97	0115-0245	6	126	12	4	37	0	27	26	3	7	0	**242**
Avg. Fish Passage - 438/h.													
7/20/97	0000-0045	3[a]	145	1	2	8	0	16	24	0	1	0	197
Avg. Fish Passage - 615/h.													
7/24/97	0115-0310	6	179	3	3	9	0	101	42	1	3	1	**342**
Avg. Fish Passage - 628/h.													
7/28/97	0055-0135	3	140	1	6	3	1	52	34 (3 recap)	0	0	1	**238**
Avg. Fish Passage - 531/h.													

[a] Only chum salmon were enumerated on the third set. The remaining fish were released without counting.

Table 6. Age and sex of beach seine caught chum salmon from Aniak River escapement samples, collected near the sonar site and applied to passage estimates by time stratum in 1997.

Year	Sample Dates (Stratum Dates)	Sample Size	Sex	Age Class 0.2 Esc.	0.2 %	0.3 Esc.	0.3 %	0.4 Esc.	0.4 %	0.5 Esc.	0.5 %	Total Esc.	Total %
1997	6/30 - 7/4	139	M	0	0.0	15,207	22.3	22,074	32.4	491	0.7	37,772	55.4
	(6/16 - 7/6)		F	491	0.7	16,679	24.5	13,245	19.4	0	0.0	30,414	44.6
			Subtotal	491	0.7	31,886	46.8	35,319	51.8	491	0.7	68,186	100.0
	7/9 - 7/12	169	M	0	0.0	13,860	32.5	8,568	20.1	252	0.6	22,680	53.3
	(7/7 - 7/13)		F	252	0.6	14,364	33.7	4,788	11.2	504	1.2	19,908	46.7
			Subtotal	252	0.6	28,224	66.3	13,356	31.4	756	1.8	42,588	100.0
	7/15 - 7/16	138	M	305	1.5	6,863	32.6	5,033	23.9	0	0.0	12,201	58.0
	(7/14 - 7/17)		F	305	1.4	5,033	23.9	3,507	16.7	0	0.0	8,845	42.0
			Subtotal	610	2.9	11,896	56.5	8,540	40.6	0	0.0	21,046	100.0
	7/20	124	M	0	0.0	20,504	37.1	6,686	12.1	0	0.0	27,189	49.2
	(7/18 - 7/22)		F	446	0.8	19,166	34.7	8,023	14.5	446	0.8	28,081	50.8
			Subtotal	446	0.8	39,669	71.8	14,709	26.6	446	0.8	55,270	100.0
	7/24	156	M	0	0.0	7,620	32.7	3,138	13.5	0	0.0	10,758	46.2
	(7/23 - 7/26)		F	598	2.6	9,263	39.7	2,689	11.5	0	0.0	12,550	53.8
			Subtotal	598	2.6	16,883	72.4	5,827	25.0	0	0.0	23,308	100.0
	7/28	127	M	0	0.0	17,238	33.1	2,873	5.5	0	0.0	20,111	38.6
	(7/27 - 8/3)		F	1,231	2.4	26,267	50.4	4,515	8.7	0	0.0	32,013	61.4
			Subtotal	1,231	2.4	43,505	83.5	7,388	14.2	0	0.0	52,124	100.0
	Season	853	M	305	0.1	81,291	30.9	48,372	18.4	743	0.3	130,711	49.8
			F	3,323	1.3	90,772	34.6	36,766	14.0	950	0.3	131,810	50.2
			Total	3,628	1.4	172,063	65.5	85,138	32.4	1,693	0.6	262,522	100.0

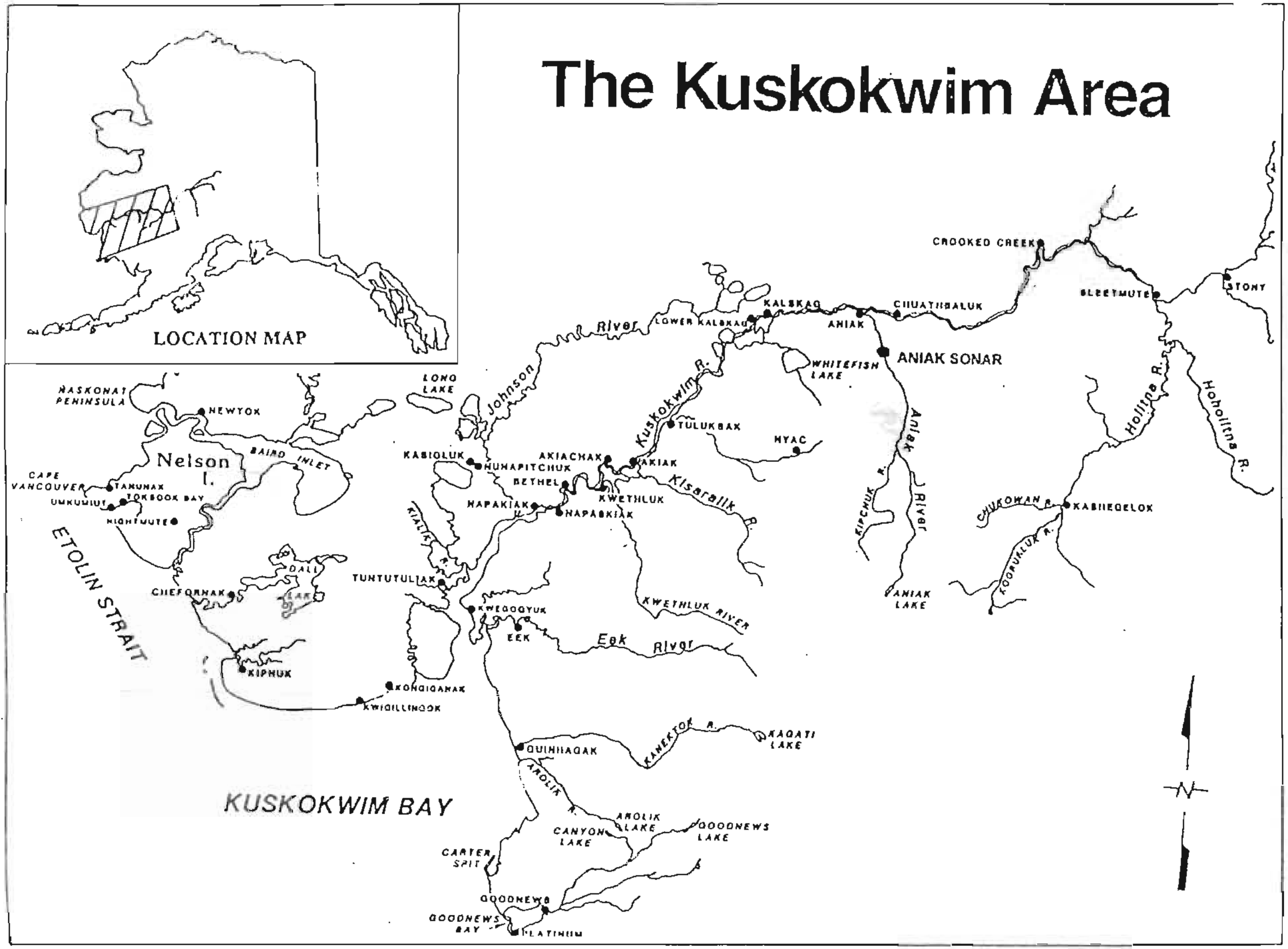


Figure 1. Map of the Kuskokwim Area.

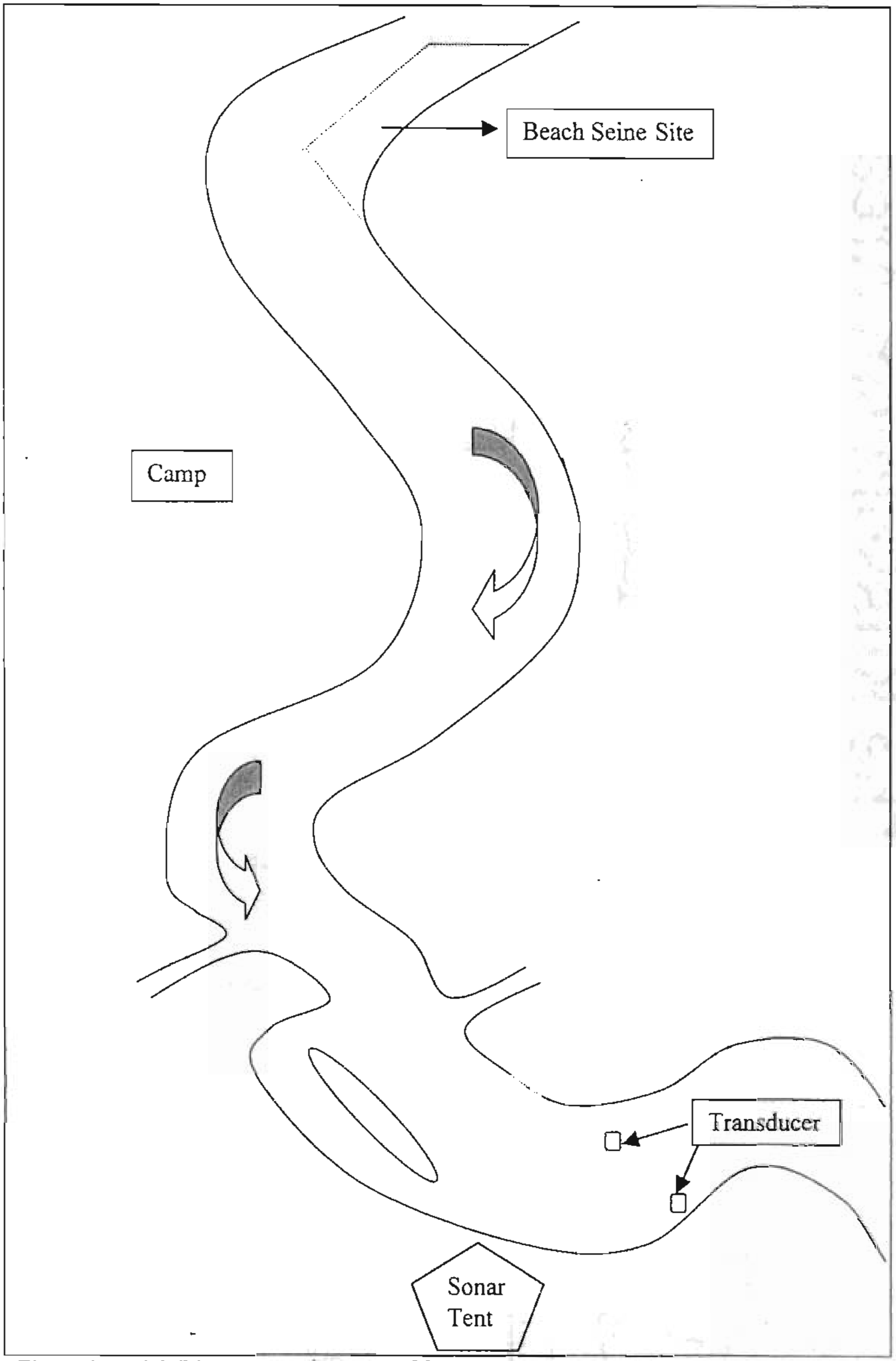


Figure 2. Aniak River sonar site map, 1997.

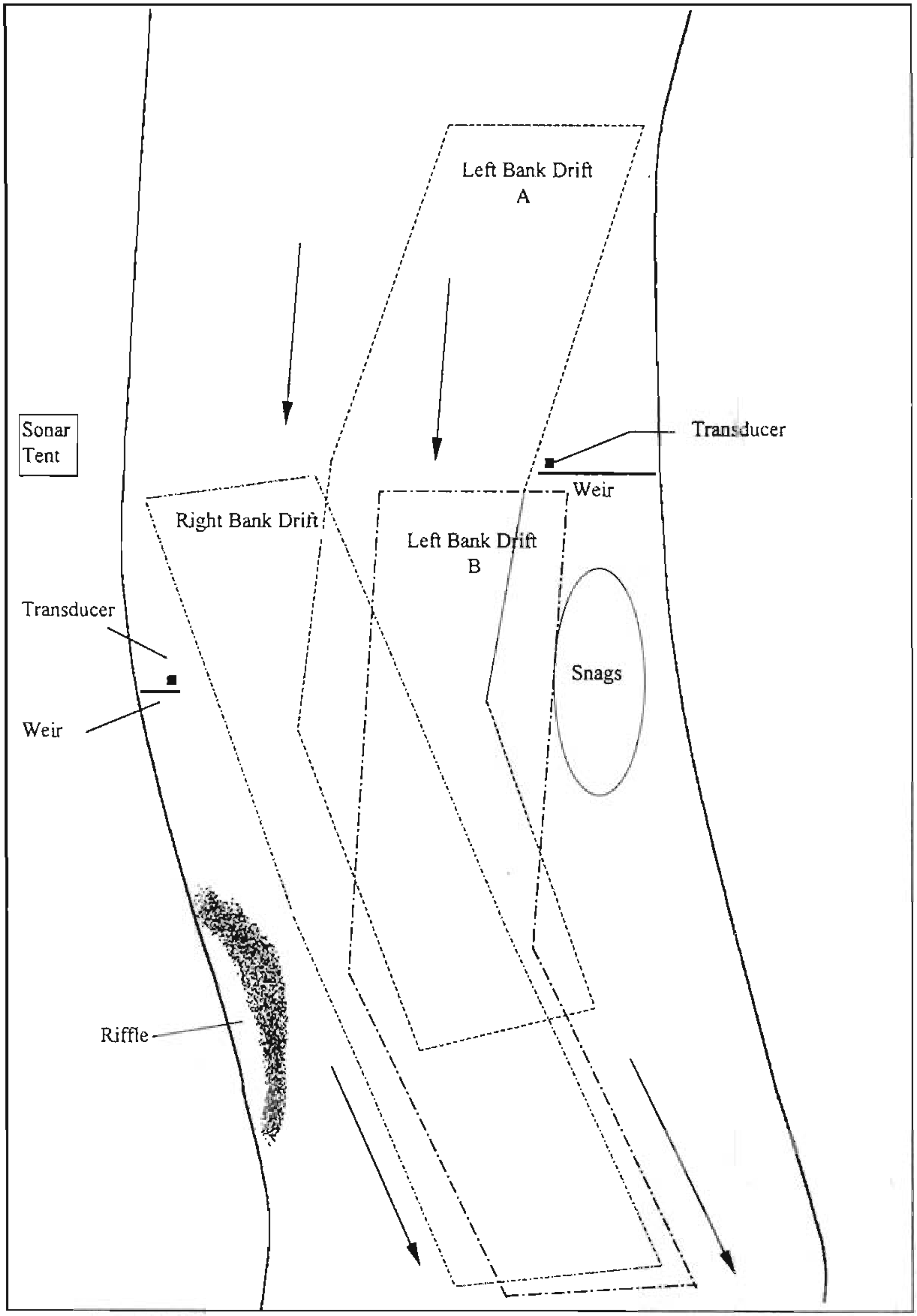


Figure 3. Aniak River drift gillnet stations, 1997.

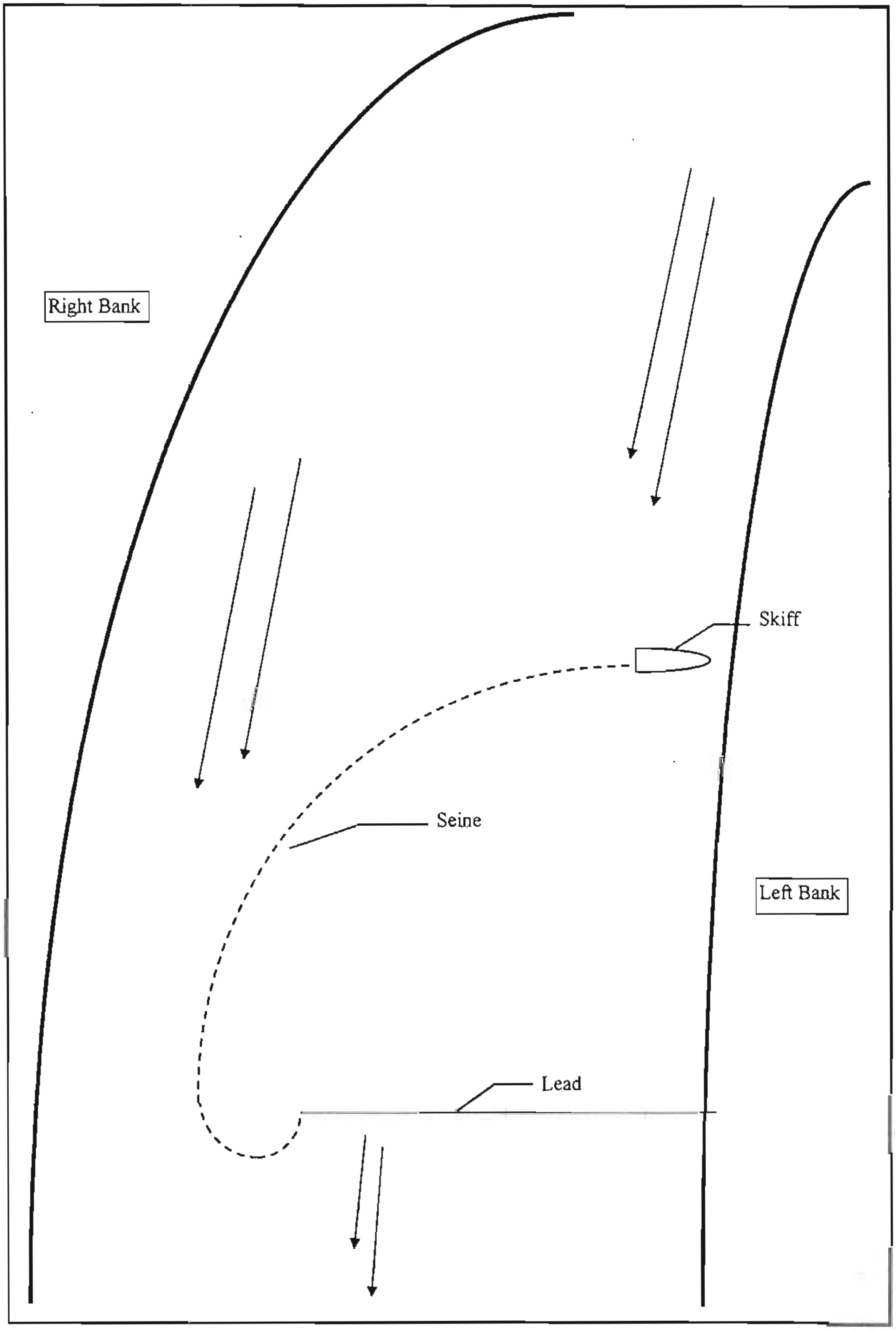
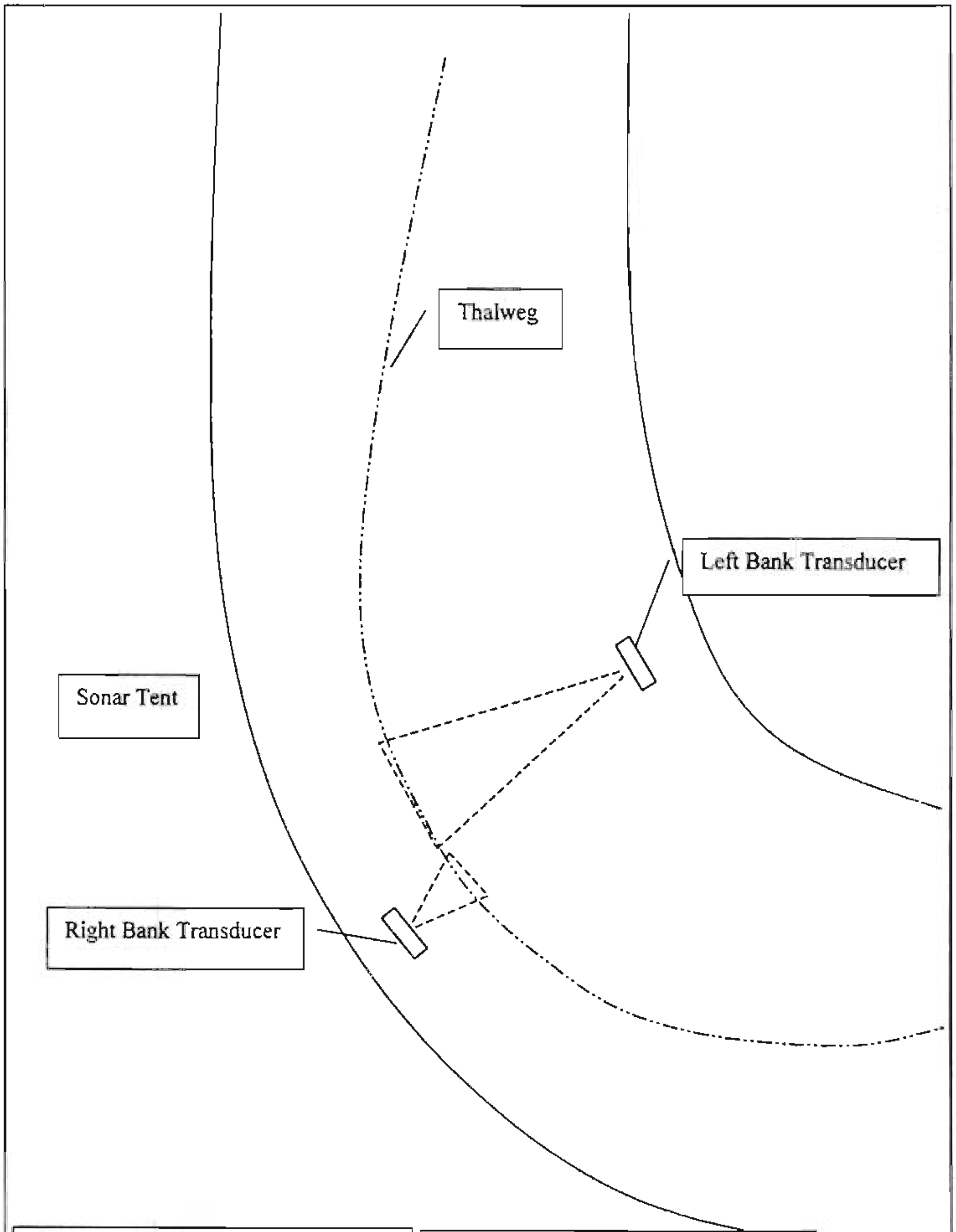


Figure 4. Beach seine deployment method, Aniak River , 1997.



Measured on 6/26/97
LB Ensonified Range: 40 m
RB Ensonified Range: 15 m
Distance between Transducers: 55.4 m
LB Ducer to Thalweg: 35 m
RB Ducer to Thalweg: 13 m.
Max. Depth of River: 2.2 m
LB Aim: 329°
RB Aim: 175°

Measured on 7/14/97
LB Ensonified Range: 30 m
RB Ensonified Range: 12 m
Distance between Transducers: 44.5 m
LB Ducer to Thalweg: 25 m
RB Ducer to Thalweg: 9 m.
Max. Depth of River: 2.2 m
LB Aim: 316°
RB Aim: 175°

Figure 5. Aniak River sonar site stream measurements, 1997.

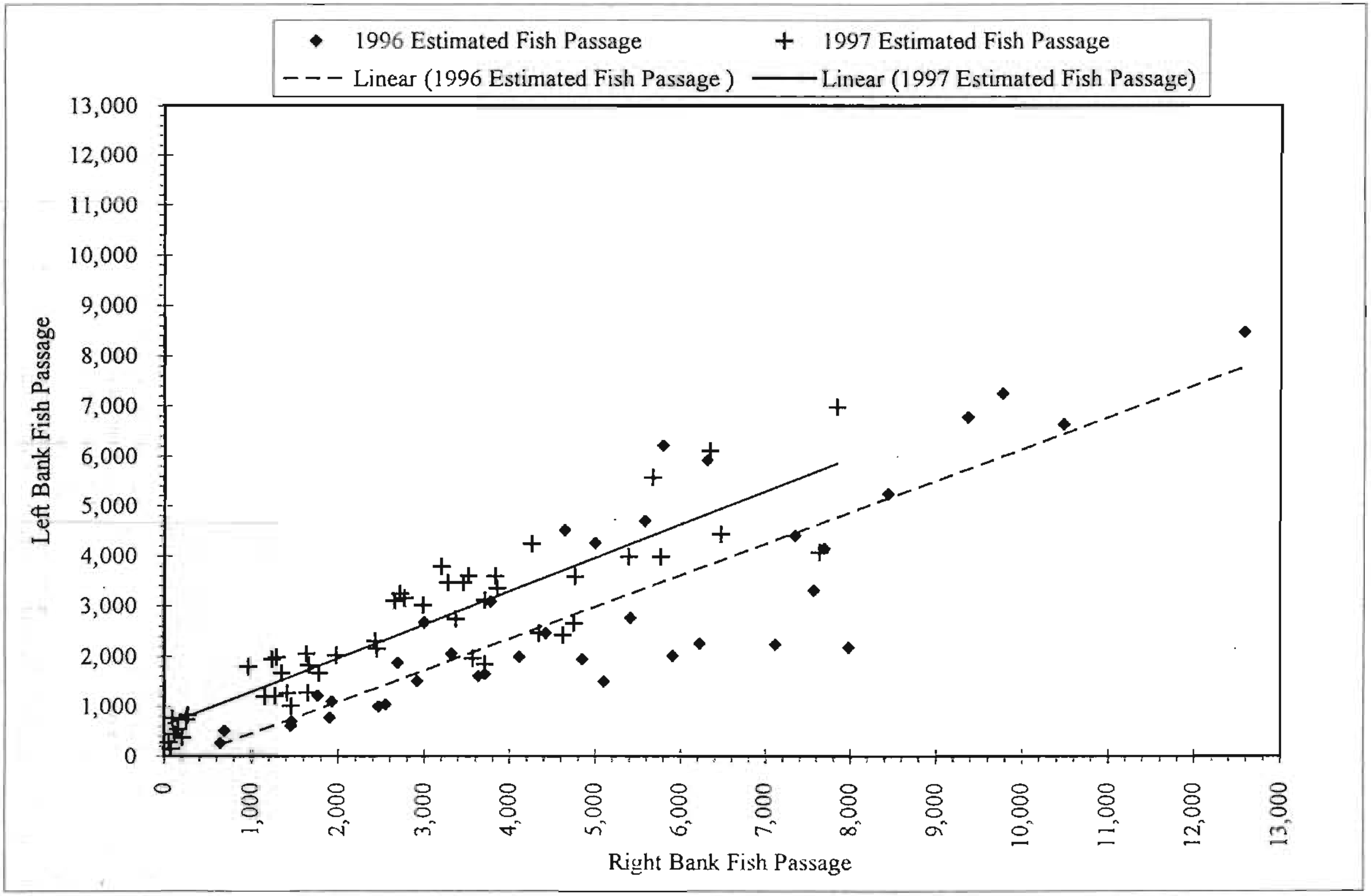


Figure 6. Estimated daily fish passage, Aniak River sonar, 1996-1997.

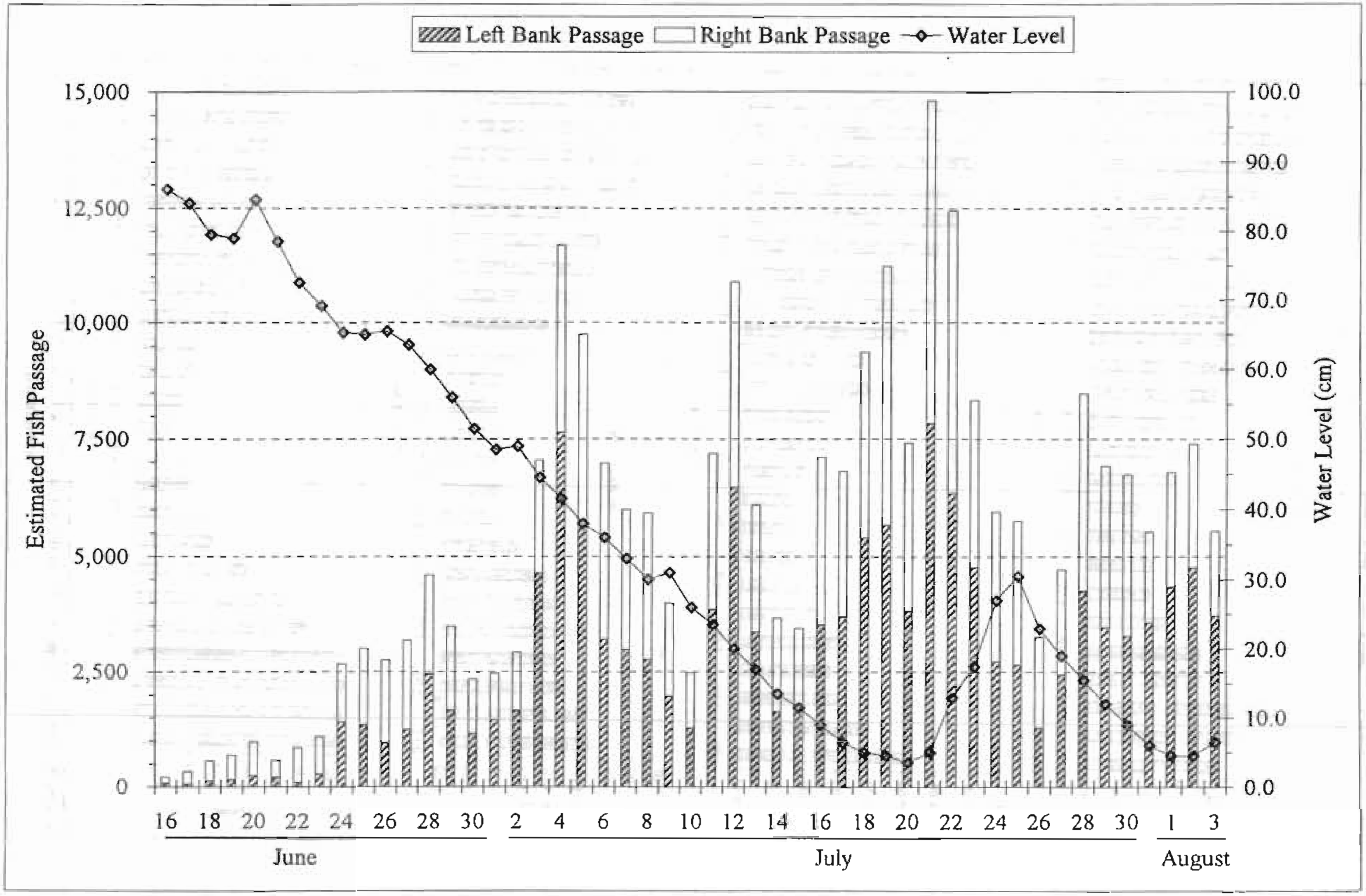


Figure 7. Estimated daily fish passage and measured water levels, Aniak River, 1997.

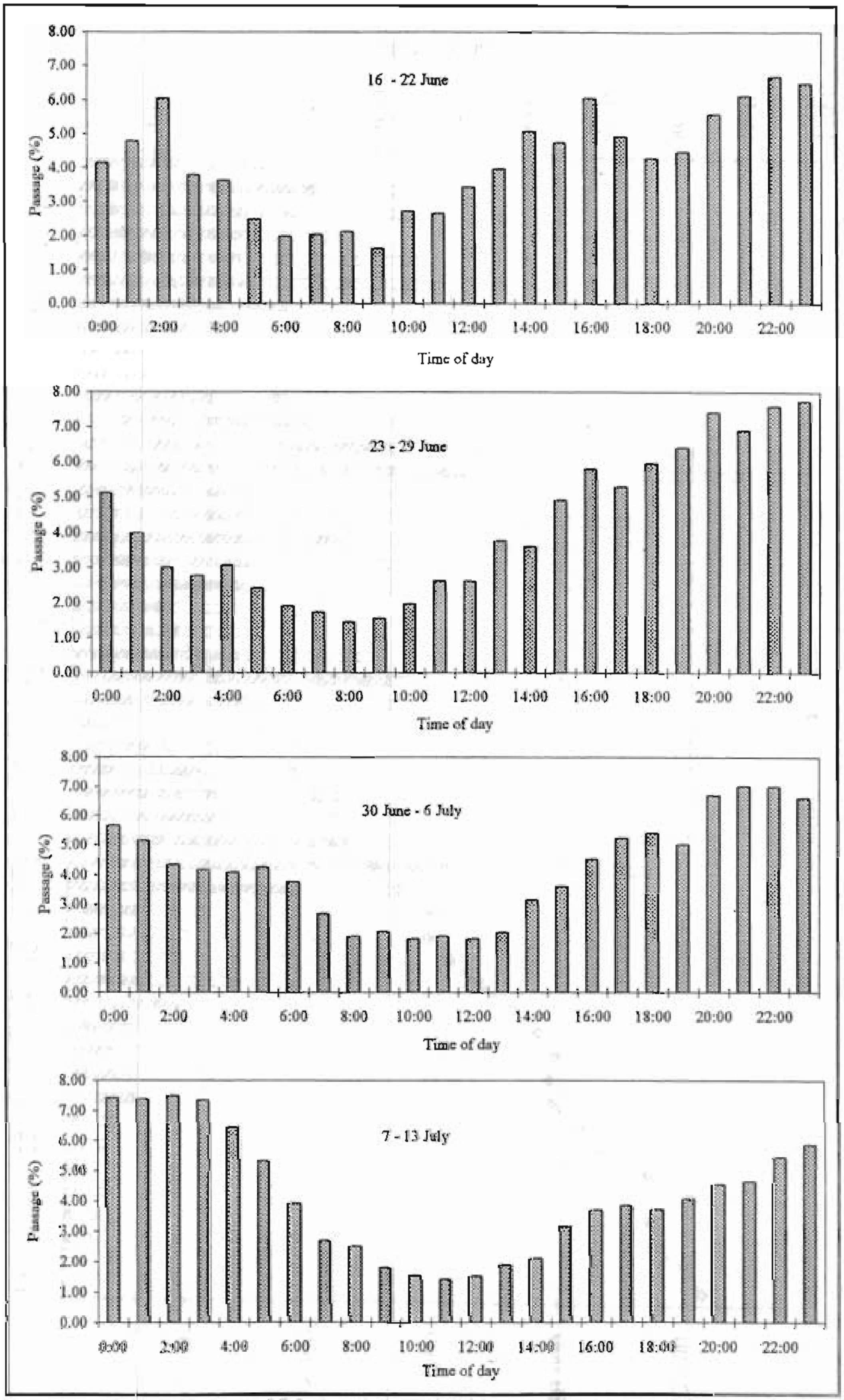


Figure 8. Diel distributions of fish detections, Aniak River, 1997.
(continued)

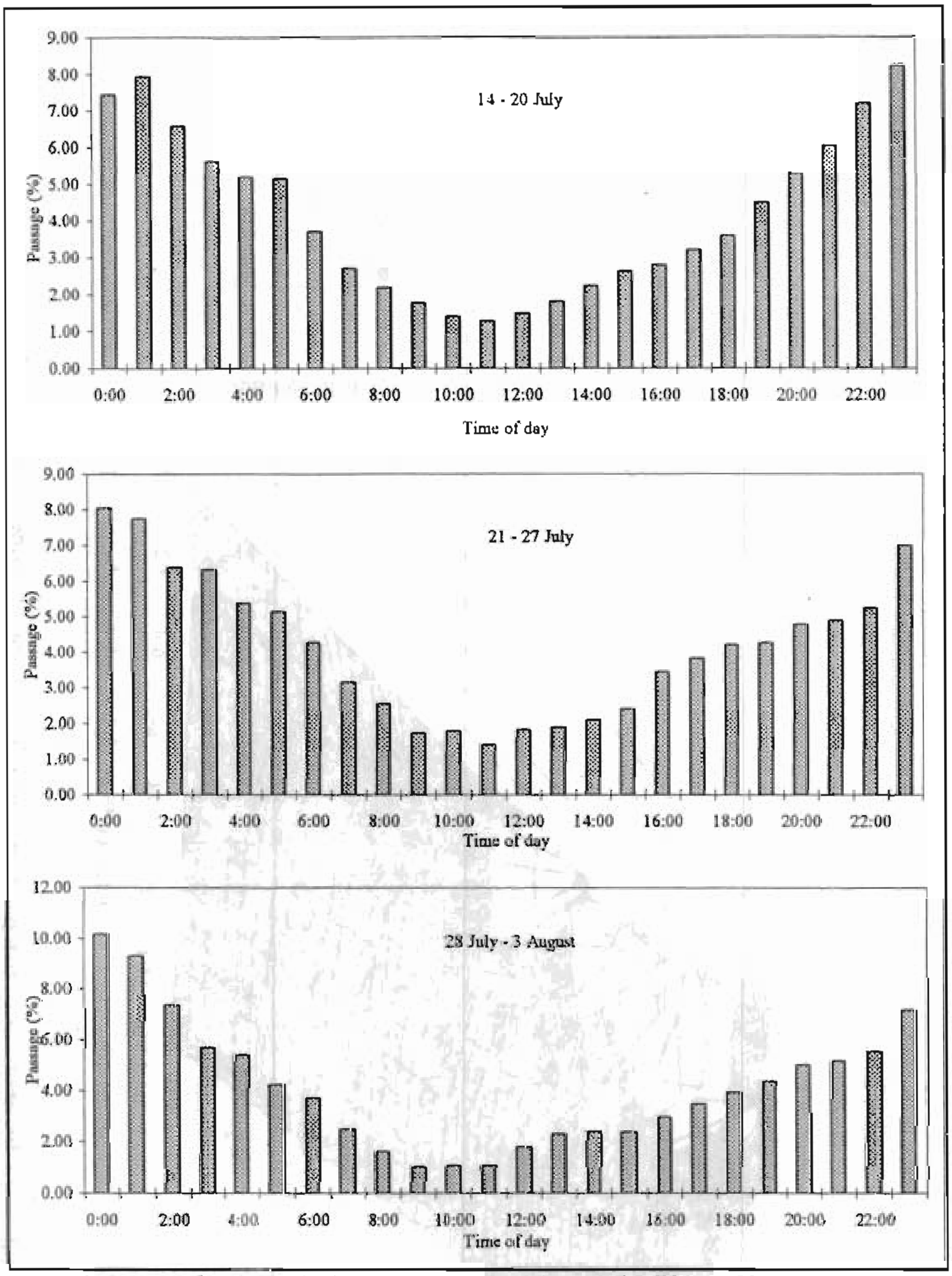


Figure 8. (page 2 of 2) Diel distributions of fish detections, Aniak River, 1997.

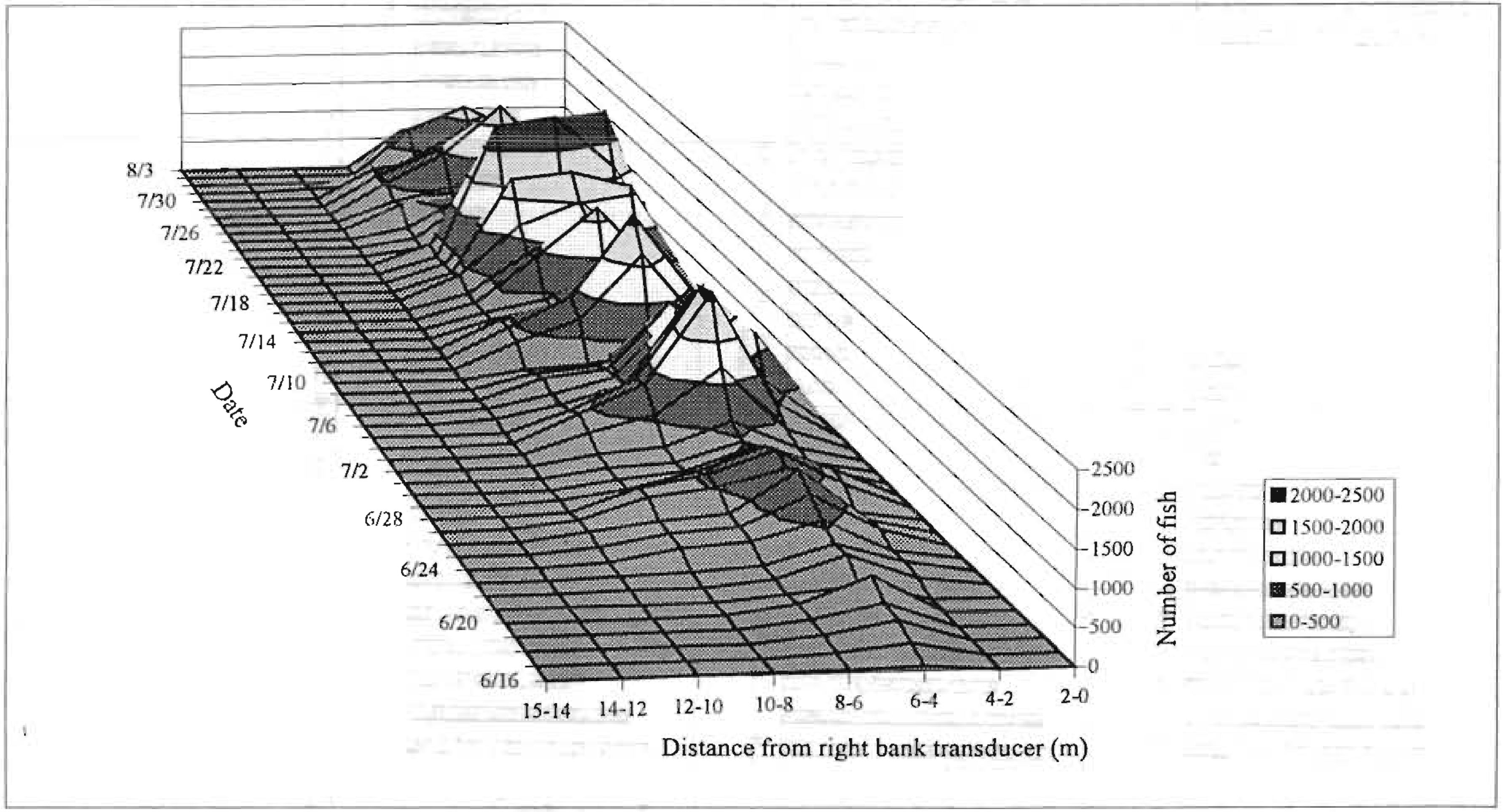


Figure 10. Right bank horizontal range distributions of fish passage, Aniak River sonar, 16 June - 3 August, 1997.

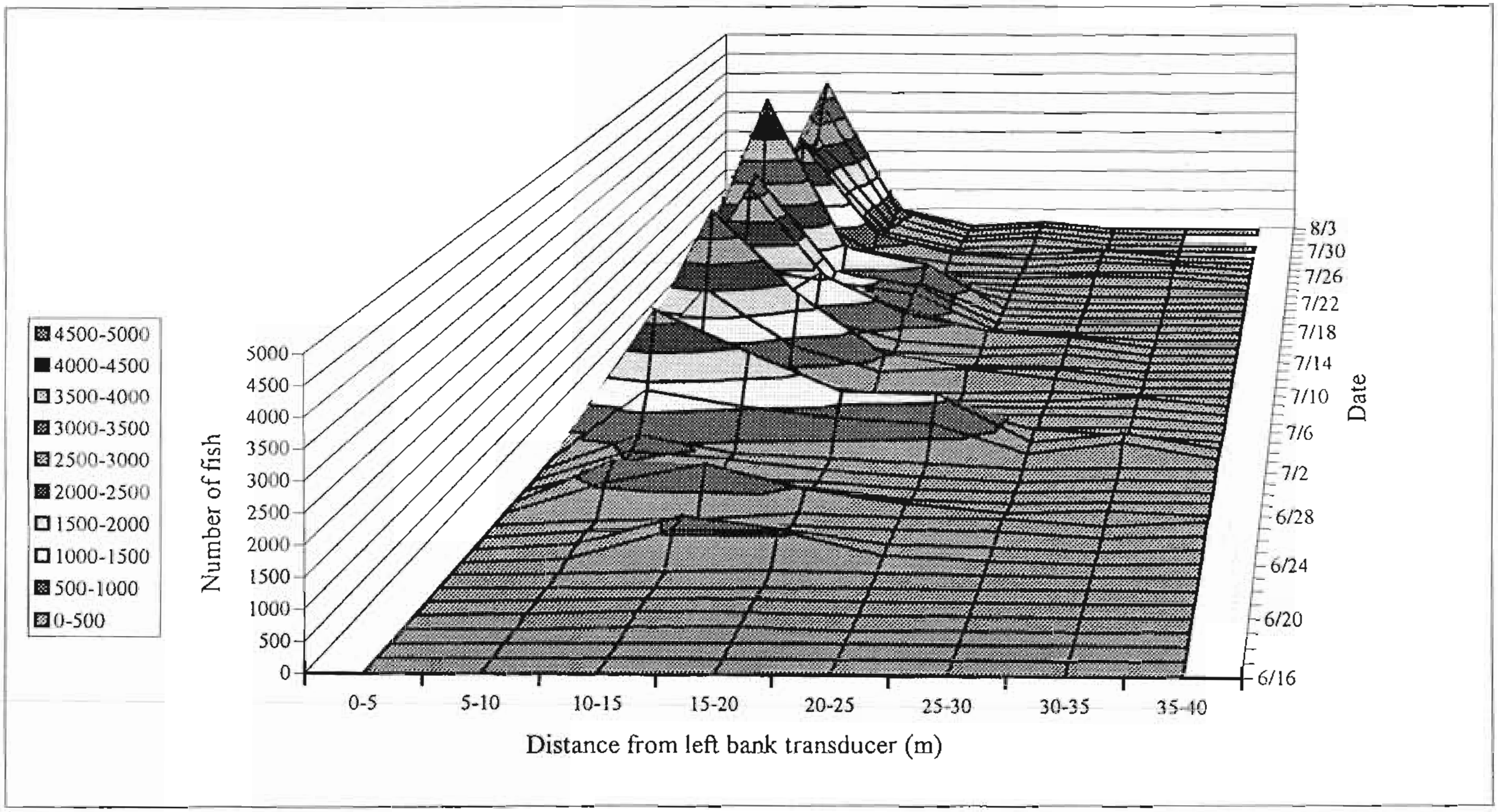


Figure 11. Left bank horizontal range distributions of fish passage, Aniak River sonar, 16 June - 3 August, 1997.

APPENDIX A

Appendix A.1 Timetable of developmental changes at the Aniak Sonar Project, 1980-1997.

YEAR	EVENT
1980	• Aniak sonar project established • 1978 model, non-configurable Bendix sonar counter used with 60 ft artificial substrate. • Single bank operation (1980-95). • Cumulative adjusted daily sonar estimates expanded by 150% to account for salmon passing outside the ensonified area. • Sonar estimates are extrapolated for pre and post season salmon escapement (1980-82, 85-89, 91-96). • Gillnet test fishing to provide species apportionment and ASL information. • Three correction factor calibrations per day averaged to adjust daily estimates.
1981	• 1981 model, non-configurable Bendix sonar counter used with 60 ft artificial substrate. • A tentative escapement objective of 250,000 chum and 25,000 king salmon is established for the Aniak River. • Gillnet and beach seine test fishing to provide species apportionment and ASL information.
1982	• Sonar equipment unchanged. • Escapement objective of 250,000 chum and 25,000 king salmon escapement are established for the Aniak River. • Gillnet test fishing to provide species apportionment and ASL information. • Four correction factor calibrations applied to 6 hour time periods to adjust daily estimates.
1983	• Sonar equipment unchanged. • Review of escapement objective based upon sonar estimates indicated 1980-81 Aniak sonar estimates likely represented record escapements, and much smaller escapements would probably provide adequate future spawning stocks as well as sustained harvest. Objectives remain 250,000 chum and 25,000 king salmon. • Sonar estimates are not extrapolated for pre and post season salmon escapement (1983-84, 90, 96-97).
1984	• Sonar equipment unchanged. • No apportionment of estimates made due to insufficient test gillnet catches. In the absence of sufficient species apportionment data, the sonar based escapement objective would be 250,000 estimated salmon counts. • Cumulative adjusted daily sonar estimates expanded by 162% to account for salmon passing outside the ensonified area.

-Continued-

Appendix A.1 (Page 2 of 2)

YEAR	EVENT
1985	• Sonar equipment unchanged. • Gillnet test fishing and carcass samples provide ASL information.
1986	• Sonar equipment unchanged. • ASL sampling activities are discontinued to decrease operating costs. • Species apportionment activities are discontinued due to inadequate sample sizes.
1988	• Sonar operations eliminated use of the 60 ft artificial substrate. Sampling range unknown.
1989	• Sonar operations same as 1988.
1990	• No formal project documentation (1990-95).
1993	• Fire destroys 1981 model Bendix sonar counter. Replaced with a 1978 model Bendix sonar counter. • Historic data in Kuskokwim Area Management Report is adjusted to reflect 162% expansion factor applied to 1980-83 season estimates.
1994	• Sonar operations continue with 1978 model counter.
1995	• Sonar operations continue with 1978 model counter. • Reliable escapement estimates are not generated.
1996	• Established a new sonar data collection site 1.5 km downstream from the historical site. • Project operations redesigned to provide full river ensonification, with user configurable sonar equipment 24 hours per day on both banks. • Periodic net sampling to monitor broad changes in species composition, corroborate acoustically detected abundance trends, and obtain ASL samples of chum salmon. • Sonar estimates are not extrapolated for pre and post season salmon escapement (1996-97). • Regional Information Report documents project operations and data collection activities.
1997	• Project operations remain the same as 1996.

Appendix A.2 Estimated daily fish passage per range strata, Aniak River sonar, 16 June - 3 August, 1997.

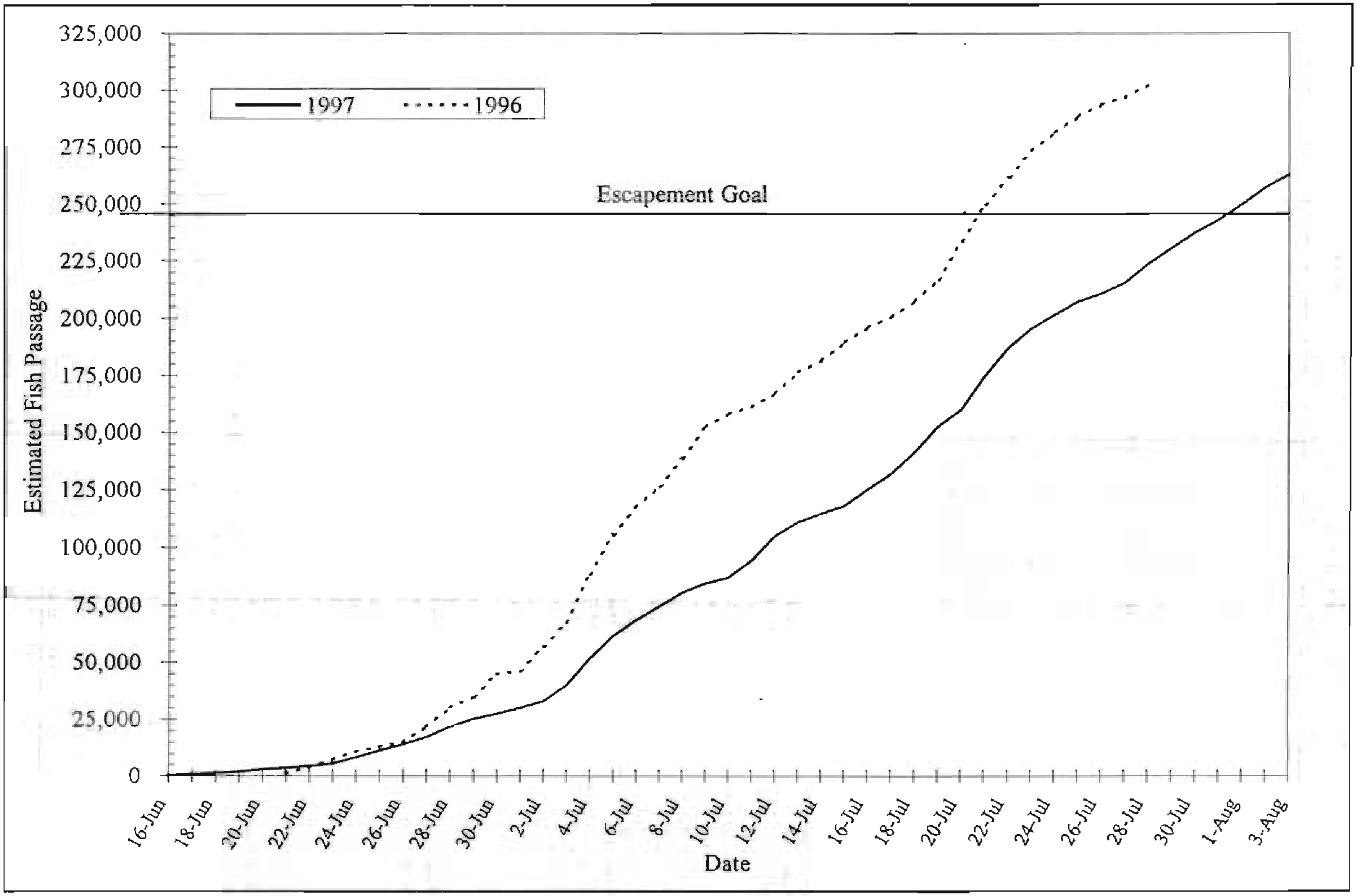
Left bank fish passage/strata

Strata	1	2	3	4	5	6	7	8	Comments
	Distance from left bank transducer (m)								
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	
16-Jun	0	2	12	8	23	10	4	2	@15' of weir, thalweg @ 32m
17-Jun	0	3	13	9	12	8	5	0	
18-Jun	1	13	18	24	29	20	10	2	
19-Jun	0	5	50	63	11	14	1	10	
20-Jun	1	26	79	68	38	16	5	11	
21-Jun	0	17	60	59	25	19	10	8	
22-Jun	0	5	14	18	23	16	12	3	
Week Total	**2**	**71**	**246**	**249**	**161**	**103**	**47**	**36**	
Passage (%)	**0.22**	**7.76**	**26.89**	**27.21**	**17.60**	**11.26**	**5.14**	**3.93**	
23-Jun	0	12	59	82	59	33	12	13	thalweg @ 37m, reaimed ducer
24-Jun	1	50	558	554	141	63	9	34	
25-Jun	2	96	594	364	119	77	18	55	
26-Jun	0	111	178	232	175	146	42	80	
27-Jun	1	82	123	238	186	169	42	134	moved ducer out @ 2m, thalweg @ 35m
28-Jun	7	562	909	462	227	64	115	28	changed to Tx on WB.
29-Jun	12	758	370	282	88	33	61	54	
Week Total	**23**	**1671**	**2791**	**2214**	**995**	**585**	**299**	**398**	
Passage (%)	**0.26**	**18.62**	**31.09**	**24.67**	**11.09**	**6.52**	**3.33**	**4.43**	
30-Jun	7	484	247	197	81	32	67	36	
1-Jul	3	554	408	216	111	26	73	48	
2-Jul	17	657	328	246	157	65	92	88	
3-Jul	24	1360	1047	829	727	163	388	72	
4-Jul	17	2747	1924	1163	1109	196	379	84	
5-Jul	16	2328	1201	1015	675	262	154	28	chged range to 35 m, moved ducer out, 15' of weir.
6-Jul	93	1912	388	328	121	101	115		
Week Total	**177**	**10042**	**5543**	**3994**	**2981**	**845**	**1268**	**356**	
Passage (%)	**0.70**	**39.84**	**21.99**	**15.85**	**11.83**	**3.35**	**5.03**	**1.41**	
7-Jul	29	1798	403	274	164	173	138		
8-Jul	65	1675	382	230	142	142	134		
9-Jul	35	1228	254	128	71	84	175		
10-Jul	2	421	156	55	57	104	48		chnged range to 30m, moved ducer out,
11-Jul	0	2044	858	325	393	197			thaweg @ 26m; 8m of weir
12-Jul	0	3567	1791	508	248	219			
13-Jul	4	467	287	124	112	101			
Week Total	**135**	**11200**	**4131**	**1644**	**1187**	**1020**	**495**	**0**	
Passage (%)	**0.68**	**56.53**	**20.85**	**8.30**	**5.99**	**5.15**	**2.50**	**0.00**	
14-Jul	5	471	576	214	149	201			
15-Jul	7	291	792	301	157	205			
16-Jul	1	550	1605	743	357	241			
17-Jul	69	1420	1175	632	153	88			move ducer out.Thalweg @ 20 m
18-Jul	104	3192	1093	848	56	0			
19-Jul	149	3369	1183	857	43	0			
20-Jul	132	2167	747	738	34	0			
Week Total	**467**	**11460**	**7171**	**4333**	**949**	**735**	**0**	**0**	
Passage (%)	**1.86**	**45.63**	**28.55**	**17.25**	**3.78**	**2.93**	**0.00**	**0.00**	
21-Jul	254	4845	1442	1048	35	0			
22-Jul	941	3712	817	574	61	1			ducer & weir moved in. Thalweg @ 23 m
23-Jul	1332	2663	316	301	101	0			
24-Jul	383	1421	345	167	94	87	63		moved pod in. Changed range to 35 m
25-Jul	4	1419	487	162	101	175	138		15' of weir, thalweg @ 32m
26-Jul	5	613	275	93	70	110	116		
27-Jul	8	1395	426	152	61	194	126		ducer out, 18' of weir, thalweg @ 32m
Week Total	**2927**	**16068**	**4108**	**2497**	**523**	**567**	**443**	**0**	
Passage (%)	**10.79**	**59.22**	**15.14**	**9.20**	**1.93**	**2.09**	**1.63**	**0.00**	
28-Jul	14	2910	715	246	94	188	60		
29-Jul	26	2462	509	137	66	183	33		
30-Jul	12	2506	474	69	129	49	0		moved ducer out,thalweg @25 m. 20' of weir
31-Jul	12	2680	538	92	214	24	0		
1-Aug	9	3368	562	65	196	20	9		
2-Aug	2	3817	601	89	200	28	0		
3-Aug	20	2957	491	65	160	6	0		
Week Total	**95**	**20700**	**3890**	**763**	**1059**	**498**	**102**	**0**	
Passage (%)	**0.35**	**76.36**	**14.35**	**2.81**	**3.91**	**1.84**	**0.38**	**0.00**	
Season Total	3826	71212	27880	15694	7855	4353	2654	790	
Passage (%)	2.85	53.04	20.77	11.69	5.85	3.24	1.98	0.59	

(continued)

Right bank fish passage/strata

Strata	1	2	3	4	5	6	7	8	Comments
	Distance from right bank transducer (m)								
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-15	
16-Jun	0	0	67	32	23	16	3	0	
17-Jun	0	1	171	67	16	12	3	0	
18-Jun	0	2	284	116	17	16	3	0	
19-Jun	0	0	333	140	27	19	8	0	
20-Jun	0	13	505	162	33	15	2	0	thalweg @ 12.3m
21-Jun	0	1	205	108	24	16	9	0	
22-Jun	0	106	441	133	40	33	6	0	
Week Total	**0**	**123**	**2006**	**758**	**180**	**127**	**34**	**0**	
Passage (%)	**0.00**	**3.81**	**62.14**	**23.48**	**5.58**	**3.93**	**1.05**	**0.00**	
23-Jun	0	146	411	143	75	39	3	0	
24-Jun	0	123	546	294	227	58	6	0	
25-Jun	0	242	729	325	251	90	6	1	
26-Jun	0	195	893	322	244	129	6	0	
27-Jun	0	126	757	515	405	119	18	0	
28-Jun	0	347	841	520	363	49	4	0	moved ducer out
29-Jun	0	397	730	398	178	47	0	0	
Week Total	**0**	**1576**	**4907**	**2517**	**1743**	**531**	**43**	**1**	
Passage (%)	**0.00**	**13.92**	**43.36**	**22.24**	**15.40**	**4.69**	**0.38**	**0.01**	
30-Jun	0	223	565	241	147	13	0	0	changed Range to 14m - removed strata 8.
1-Jul	0	162	477	200	150	15	0		
2-Jul	0	202	599	261	177	31	0		
3-Jul	0	307	1189	558	320	34	0		
4-Jul	9	518	2105	838	436	30	1		moved weir out, @14' of weir.
5-Jul	0	666	2032	740	327	19	0		moved ducer out, 10' of weir, chged range to 12m
6-Jul	0	1201	1760	503	249	61			
Week Total	**9**	**3279**	**8727**	**3341**	**1806**	**203**	**1**	**0**	
Passage (%)	**0.05**	**18.88**	**50.25**	**19.24**	**10.40**	**1.17**	**0.01**	**0.00**	
7-Jul	0	840	1405	474	241	52			
8-Jul	0	1008	1366	432	314	21			
9-Jul	0	627	820	324	231	14			
10-Jul	0	167	381	197	138	5			
11-Jul	0	565	1661	709	389	2			
12-Jul	0	917	2128	889	461	12			
13-Jul	0	376	1311	521	429	3			
Week Total	**0**	**4500**	**9072**	**3546**	**2203**	**109**	**0**	**0**	
Passage (%)	**0.00**	**23.16**	**46.69**	**18.25**	**11.34**	**0.56**	**0.00**	**0.00**	
14-Jul	0	277	1014	435	284	10			
15-Jul	0	236	751	425	236	1			moved ducer out.
16-Jul	0	703	1691	942	244	4			
17-Jul	0	616	1347	851	246	3			
18-Jul	0	754	1517	1153	394	9			narrow beam cabled damaged by beaver
19-Jul	0	1620	1857	1756	283	0			
20-Jul	0	676	1281	1348	282	0			
Week Total	**0**	**4882**	**9458**	**6910**	**1969**	**27**	**0**	**0**	
Passage (%)	**0.00**	**21.00**	**40.69**	**29.73**	**8.47**	**0.12**	**0.00**	**0.00**	
21-Jul	3	1672	2484	2357	257	0			
22-Jul	0	2432	1788	1395	326	0			
23-Jul	0	1232	792	582	123	0			
24-Jul	0	1459	828	797	139	0			
25-Jul	0	1232	864	697	172	4			moved ducer in, @15' weir, thalweg @10m
26-Jul	0	531	655	325	427	23			
27-Jul	0	515	848	560	347	18			
Week Total	**3**	**9073**	**8259**	**6713**	**1791**	**45**	**0**	**0**	
Passage (%)	**0.01**	**35.05**	**31.91**	**25.93**	**6.92**	**0.17**	**0.00**	**0.00**	
28-Jul	0	896	1785	996	528	9			
29-Jul	0	815	1167	927	530	8			moved ducer out, @10' weir.
30-Jul	0	814	824	627	500	4			moved ducer & weir out, @11' weir
31-Jul	0	444	943	452	69	46			
1-Aug	0	598	939	421	0	0			
2-Aug	0	718	1152	766	1	0			
3-Aug	0	494	711	633	0	0			
Week Total	**0**	**4779**	**7521**	**4822**	**1628**	**67**	**0**	**0**	
Passage (%)	**0.00**	**25.40**	**39.97**	**25.63**	**8.65**	**0.36**	**0.00**	**0.00**	
Season Total	12	28212	49950	28607	11320	1109	78	1	
Passage (%)	0.01	23.65	41.87	23.98	9.49	0.93	0.07	0.00	



Appendix A.3 Estimated cumulative fish passage, Aniak River sonar, 1996 - 1997.

Appendix A.4 Climatological and hydrologic measurements, Aniak River sonar site, 1997.

e	Time	Water (C)	Air (C)	Secchi (m)	H_2O Level (cm)	Rain (mm)	Wind Vel/Dir.	Conductivity (microsiemens)	General Conditions (sunny, overcast, intermittent rain, heavy rain, etc....)
Jun	1145	10.2	20.0	0.75	N/A	0	10-15/S	87.5	Sunny - 20% cloud cover. Min 10°
16-Jun	1026	10.8	19.2	0.9	86.0	0	0	82.3	Overcast
17-Jun	0939	10.4	13.2	1.1	84.0	0	0	86.2	Partly sunny
18-Jun	0900	11.4	12.3	1.0	79.5	0	0	83.0	Overcast
19-Jun	0840	11.3	9.8	1.2	79.0	0	5/SE	81.6	Sunny with slight overcast. Min 4°, Max 22°
20-Jun	0845	11.9	11.9	1.0	84.5	0	10	82.3	Sunny with scattered clouds. Min 4°, Max 18°
21-Jun	0900	11.0	7.6	1.1	78.5	0	5/NE	82.6	Sunny with slight overcast.
22-Jun	0845	10.2	7.4	1.0	72.5	0	5	85.3	Solid overcast. Min 8°
23-Jun	0830	11.4	10.2	1.15	69.1	0	0-Jan	80.1	Mostly sunny.
24-Jun	0820	13.1	10.8	1.1	65.3	0	0	83.0	Clear with smoke haze.
25-Jun	0825	13.1	14.4	1.1	65.0	0	0	83.5	Solid overcast. Min 9°, Max 28°
26-Jun	0821	13.0	12.8	1.4	65.5	2	0	82.3	Sunny, clear skies. Min 10°, Max 20°
27-Jun	0815	13.7	11.6	1.5	63.5	0	10/W	83.1	Sunny, clear skies. Min 8°, Max 22°
28-Jun	0833	13.9	10.5	1.5	60.0	0	0	86.0	Sunny, clear skies. Min 7°, Max 24°
29-Jun	0820	13.8	10.4	1.6	56.0	0	0	87.9	Sunny, clear skies. Min 8°, Max 27°
30-Jun	0818	13.8	13.5	1.6	51.5	0	0	90.1	Overcast. Min 7°, Max 27°
1-Jul	0820	12.8	14.8	1.6	48.5	1	0	90.1	Overcast, partly sunny. Min 12°, Max 20°
2-Jul	0825	13.3	16.0	1.5	49.0	5	0	87.0	Overcast w/ scattered showers. Min 11°, Max 23°
3-Jul	0840	13.4	15.5	1.5	44.5	6	0	87.4	Partly cloudy. Min 12°, Max 23°
4-Jul	0930	14.4	15.4	1.7	41.5	0	0	90.6	Sunny. Min 12°, Max 27°
5-Jul	0850	15.2	16.1	1.7	38.0	0	0	90.3	Sunny. Min 12°, Max 29°
6-Jul	0830	15.2	17.3	1.7	36.0	0	0	90.1	Partly sunny. Min 14°, Max 29°
7-Jul	0835	14.1	14.3	1.5	33.0	0	0	90.4	Sunny with smoke haze. Min 12°, Max 25°
8-Jul	0840	14	15.2	1.5	30.0	0	10-15	90.3	50% cloud cover. Min 12°, Max 22°
9-Jul	0830	12.9	15.0	2.5	31.0	0	0-5/S	91.3	Overcast, 1500 ft ceiling.
Jul	0905	12.0	14.0	2.5	26.0	0	0	92.4	Overcast, 1500 ft ceiling. Min 8°, Max 17°
Jul	0945	12.8	10.4	2.5	23.5	0	0	93.0	2000ft broken skies. Min 8°, Max 19°
12-Jul	0915	13.1	11.9	2.5	20.0	0	0	93.5	Clear skies. Min 9°, Max 21°
13-Jul	0833	12.3	9.0	2.0	17.0	0	0	89.5	Cloudy. Min 9°, Max 21°
14-Jul	0830	11.8	13.4	2.0	13.5	0	0	95.7	Cloudy. Min 8°, Max 20°
15-Jul	0820	11.0	13.8	2.0	11.5	0	0	93.4	Clear skies with smoke haze.Max 21°
16-Jul	0830	11.5	9.8	2.0	9.0	0	5/SE	93.9	Clear skies with smoke haze.Max 20°
17-Jul	0840	11.8	13.3	2.0	6.5	0	0	94.4	Overcast with smoke haze. Min 9°, Max 24°
18-Jul	0820	12.2	10.5	2.0	5.0	0	0	93.8	Clear skies with smoke haze. Min 8°, Max 24°
19-Jul	0810	12.8	8.1	2.0	4.5	0	0	94.4	Clear skies with smoke haze. Min 6°, Max 24°
20-Jul	0840	12.9	11.9	2.0	3.5	0.5	0	92.2	Partly cloudy with smoke haze. Min 7°, Max 22°
21-Jul	0815	13.6	11.0	2.0	5.0	10	5/SE	97.4	Partly cloudy, evening rain. Min 9°, Max 24°
22-Jul	0825	14.2	12.5	2.0	13.0	3	0	93.5	Overcast, evening rain. Min 8°, Max 23°
23-Jul	0830	13.5	15.2	1.7	17.5	8	0	94.3	Overcast, evening rain. Min 8°, Max 23°
24-Jul	0820	13.5	13.5	1.2	27.0	7	15/NE	87.5	Overcast. Min 8°, Max 23°
25-Jul	0825	13.2	12.9	1.0	30.5	0	15/NE	92.2	Overcast, light rain. Min 7°, Max 23°
26-Jul	0820	12.1	12.1	1.2	23.0	0	10/NE	100.3	1000 ft solid, rain. Min 4°, Max 21°
27-Jul	0800	11.7	10.5	1.6	19.0	0	0	91.6	1000 ft solid. Min 6°, Max 16°
28-Jul	0800	13.4	9.8	1.6	15.5	0	0	94.6	Partly cloudy. Min 6°, Max 23°
29-Jul	0800	14.1	11.2	1.5	12.0	0	0	94.1	Sunny. Min 6°, Max 27°
30-Jul	0920	14.2	16.0	1.6	9.0	0	10-15/SE	95.2	Sunny. Min 9°, Max 28°
31-Jul	0816	14.3	16.2	1.6	6.0	0	0	97.1	Mostly cloudy. Min 11°, Max 22°
1-Aug	1330	14.2	21.1	1.5	4.5	0	0	97.5	Sunny. Min 9°, Max 24°
2-Aug	0820	14.1	13.6	1.5	4.5	0	10-15/S	96.6	Mostly cloudy, evening rain. Min 11°, Max 24°
3-Aug	1530	14.2	15.3	1.3	6.5	12	5-10/S	94.6	Morning rain. Min 13°, Max 21°
4-Aug	0815	14.3	14.7	1.0	8.0	0	0	93.4	Overcast. Min 13°, Max 23°

Appendix A.5 Precision Acoustic Systems calibration data. Calibrated 23 April and 1 May, 1997.

Sounder	Cables	Transducer	Receiver Gain L	Standard Volts In	Vdet NB 40	G1 NB 40	Vdet WB 40	G1 WB 40	0 dB cal NB 40	0 dB cal WB 40
102-021	1000' Belden 702A/701A	ITC 009 Case I	0	-3	3.63	-167.41	3.95	-166.68	5.74	3.87
102-020	500' Belden 704A/703A	ITC 002 Case I	0	-3	3.74	-167.15	5.45	-163.88	4.82	4.83
102-021	1000' Belden 702A/701A	ITC 009 Case II	0	-8	3.29	-170.93	3.92	-169.41	5.75	3.86
102-020	500' Belden 704A/703A	ITC 002 Case II	0	-8	5.81	-165.99	5.66	-166.22	4.88	4.88

-Continued- Below

Sounder	Cables	Transducer	-13 dB Vs	-13 dB SL	-10 dB Vs	-10 dB SL	-6 dB Vs	-6 dB SL	-3 dB Vs	-3 dB SL	0 dB Vs	0 dB SL
102-021	1000' Belden 702A/701A	ITC 009 Case I	-2.60	212.24	0.05	214.89	4.20	219.04	7.00	221.84	10.00	224.84
102-020	500' Belden 704A/703A	ITC 002 Case I	1.92	216.76	4.87	219.71	8.59	223.43	11.20	226.04	13.90	228.74
102-021	1000' Belden 702A/701A	ITC 009 Case II	0.39	209.52	3.19	212.32	6.91	216.04	9.79	218.92	12.66	221.79
102-020	500' Belden 704A/703A	ITC 002 Case II	3.27	212.40	6.09	215.22	9.84	218.97	12.72	221.85	15.67	224.80